PB 189 757

BULK TRANSPORT OF WASTE SLURRIES TO INLAND AND OCEAN DISPOSAL SITES. VOLUME I. THE WASTE MANAGEMENT CONCEPT

Bechtel Corporation
San Francisco, California

September 1969

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PB189757

BULK TRANSPORT OF WASTE SLURRIES TO INLAND AND OCEAN DISPOSAL SITES

VOLUME I

THE WASTE MANAGEMENT CONCEPT

Inland and Ocean Disposal of Selected Wastes

September [illegible]

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F.W.P.C.A. Waste Management Study

VOLUME I

THE WASTE MANAGEMENT CONCEPT

Inland and Ocean Disposal of Selected Wastes

BECHTEL

September 1969

VOLUME 1

THE WASTE MANAGEMENT CONCEPT

Inland and Ocean Disposal of Selected Wastes

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PREFACE

Contract No. 14-12-156 was issued by the Federal Water Pollution Control Administration of the Department of the Interior to Bechtel Corporation on April 10, 1968. The purpose of the contract was to determine the technical feasibility and economics of transporting sewage treatment plant sludge and dredging spoils by currently available transport systems for both land and ocean disposal. To insure the general application of this concept, regional considerations were included. Two additional bulk waste materials, fly ash and water treatment plant sludge, were also investigated for possible inclusion in the disposal system.

The report summarizing the work under this contract has been presented in three volumes. Volume I is a detailed evaluation of two typical regional systems, the Northeast Ohio land disposal system and the Baltimore-Washington ocean disposal system. Included is a recommended demonstration plan. Volume II is concerned mainly with environmental criteria for regional waste management systems. Volume III is devoted to pipelining of waste materials, with major reference to a test program conducted under this study.

INTRODUCTION

In recent years it has become apparent that the industrial successes of American society have been achieved at a great cost to the nation in terms of environmental and social effects. Current trends indicate that unless rapid, aggressive and effective action is taken, such problems as air and water pollution, mass transit, inner city slums and crime will eventually achieve crisis proportions on a national scale.

Up to now, progress in these areas generally has been on a narrow front, as administrations have moved, under pressure, to alleviate an intolerable and specific local condition. In short, we, as a nation, have been reacting to problems, rather than acting on a broad front to develop ultimate or long-term solutions to them.

One of the many problems which modern society has inherited, and is effectively compounding, is that of disposal of waste materials. It is obvious that effective management of our wastes is essential if society is to have access to safe recreation areas and clean sources of water. At present, enormous quantities of objectionable materials ranging from raw sewage to highly toxic chemicals are discharged to the nation's waterways. The far reaching effects of these practices are well established. For example, Lake Erie is seriously polluted with municipal and industrial effluents, and was referred to recently as "the first large scale warning that we are in danger of destroying the habitability of the earth". (1)

Rhetoric, such as that given above, is quite common these days. Although this type of discussion serves to generate a necessary feeling of alarm, it is rarely accompanied by a viable course of action as to how to solve a specific pollution problem. This report addresses itself to the development of a specific waste management system which collects, transports and disposes of specific waste materials in a socially, technically, and economically satisfactory fashion. It further examines the feasibility of constructing and operating a demonstration project.

Although the emphasis in this study has been placed on the collection and transportation aspects of the waste disposal system, with a lesser effort being given to the land and ocean disposal, the waste management problem has been treated on a regional basis using a systems analysis approach. The emphasis on systems analysis provides a strong base in the collection and transportation area complementary to other more extensive work being done with land and ocean disposal. A major effort in this area is the 1.2 million dollar demonstration project by the Metropolitan Sanitary District of Greater Chicago using sewage sludge for agricultural benefit. The F. W. P. C. A. has just made a $610,000 demonstration grant for this two-year project. The studies and test work presented in these volumes were done under a $290,000 contract with the F. W. P. C. A.

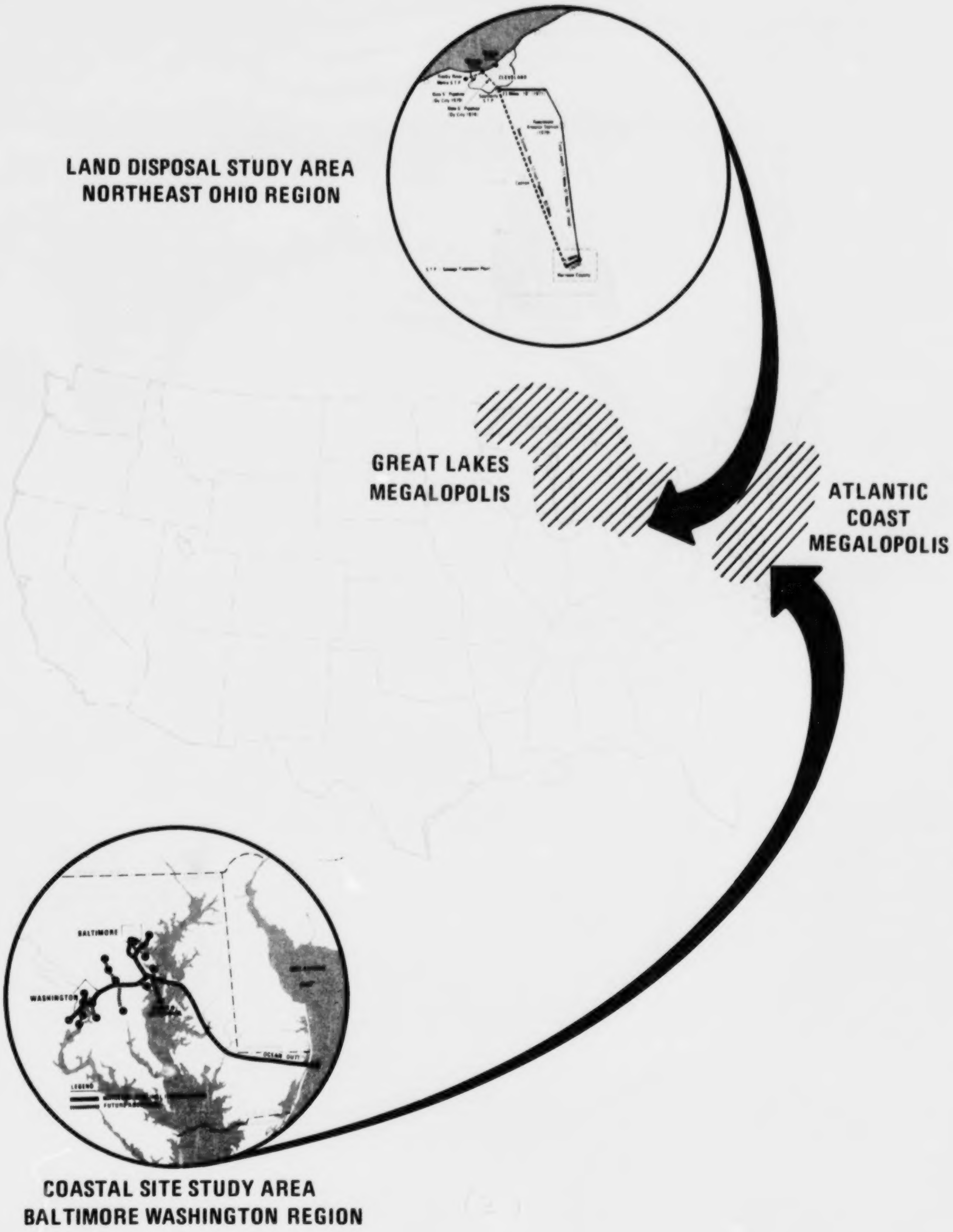
Although ocean disposal is included as a part of the systems analysis, it could not receive the effort it deserved, since the unknowns in this area are so great that extensive development work is required. Recommended future work is discussed.

The two case study areas considered in this report are presented in Figure 1. A land disposal concept is investigated for the Great Lakes Megalopolis

Figure 1

F.W.P.C.A. Waste Management Study

GENERAL LOCATION MAP


LAND DISPOSAL STUDY AREA
NORTHEAST OHIO REGION
CLEVELAND
GREAT LAKES
MEGALOPOLIS
ATLANTIC
COAST
MEGALOPOLIS
BALTIMORE
WASHINGTON
LEGEND
COASTAL SITE STUDY AREA
BALTIMORE WASHINGTON REGION

from Buffalo to Milwaukee, while ocean disposal is examined for the Atlantic Coast Megalopolis from Boston to Norfolk. The physical size of these areas is such that to realistically analyze the problem, it is necessary to concentrate on specific cases which are representative of the type of waste disposal problems encountered in the area as a whole, and which lend themselves to regional integration. The Northeast Ohio region and the Baltimore-Washington region have been selected as specific study areas. A methodology will be presented which will enable analysis of not only other regions within the study areas, but of other regions in different parts of the country.

The study is concerned mainly with the development of regional disposal systems for two specific waste materials which present a major disposal problem in many areas, namely, digested sewage sludge and maintenance dredgings. However, the study also considers, to a lesser extent, the expansion of such systems to include other wastes which lend themselves to regional disposal, such as power plant fly ash and water treatment plant sludge. Solid wastes such as trash and garbage are excluded from the study because the technology to dispose of these materials in an ecologically satisfying manner is not known.

For each detailed study case, a viable disposal system is proposed which effectively serves regional needs and is economically sound and which includes the collection, transportation and disposal of the estimated production of the subject wastes up to the year 2000. In addition, the economics of the systems are presented, and recommendations are made as how to achieve both immediate and long-term objectives.

SUMMARY AND CONCLUSIONS

This study of The Waste Management Concept investigated two specific regions; one area for land disposal considered to be representative of an inland region, and one area for ocean disposal considered representative of a coastal region. The major conclusions of the study are as follows:

- For an immediate solution to the national problem of waste disposal of digested sewage sludge, a land disposal system is recommended since it has a broad national applicability and because it does not suffer from the significant unknown factors relating to the ecological effect of disposal of large volumes of waste materials in the ocean. A long-term, successful history of using sludge on land is available.
- A regional waste management system, even if limited to sewage sludge alone, is both technically and economically feasible. Further, such a system can be significantly more effective in pollution control than local waste treatment and disposal since it can provide for the ultimate disposal of all the wastes accepted by the system in a safe and socially acceptable fashion.
- The cost benefit ratio of the sludge disposal system is so favorable that it is recommended that the Federal Government, in cooperation with the State of Ohio and the City of Cleveland, immediately embark on a demonstration project to prove the viability of the concept.
- Wastes such as dredgings, fly ash and water treatment plant sludge may also be disposed of through a regional system of

waste management. Dredging disposal costs exceed those of present methods so that implementation of this system is dependent on the value that society places on disposing of such wastes in an ecologically satisfying manner. Fly ash is often used for local land fill, but suitable sites in metropolitan areas are becoming increasingly scarce. Water treatment plant sludges, although of relatively low volume, are disposed by methods which are generally unsatisfactory. These sludges may be successfully incorporated into the disposal system through the sanitary sewers and would result in improving the system economics.

A summary of the major findings of the study is as follows:

1. Transportation Methods. Railroad, tanker, truck and pipeline transport modes were investigated. The costs of collection and transportation of the wastes studied demonstrate that pipeline transportation yields significant economies in comparison to the other modes evaluated. Only for very small plants (producing less than about 5 tons per day of solids), is waste collection by trucking more economical than pipeline transportation. A higher solids concentration than the 3.5 percent used in this study would reduce the transportation costs element for rail, tanker, and truck transport, but would be counterbalanced by the expense of concentrating. Even excluding the cost of concentrating, a concentration of 17% would have to be achieved before rail costs would be equivalent to pipeline costs at 3.5% concentration. In addition, the supernatant liquid containing nutrients and other potential pollutants still would have to be disposed of.

2. The Land Disposal Concept. The area selected for study of a land disposal system was the Northeast Ohio Region. The ultimate regional waste disposal system for this area, capable of serving the needs of this

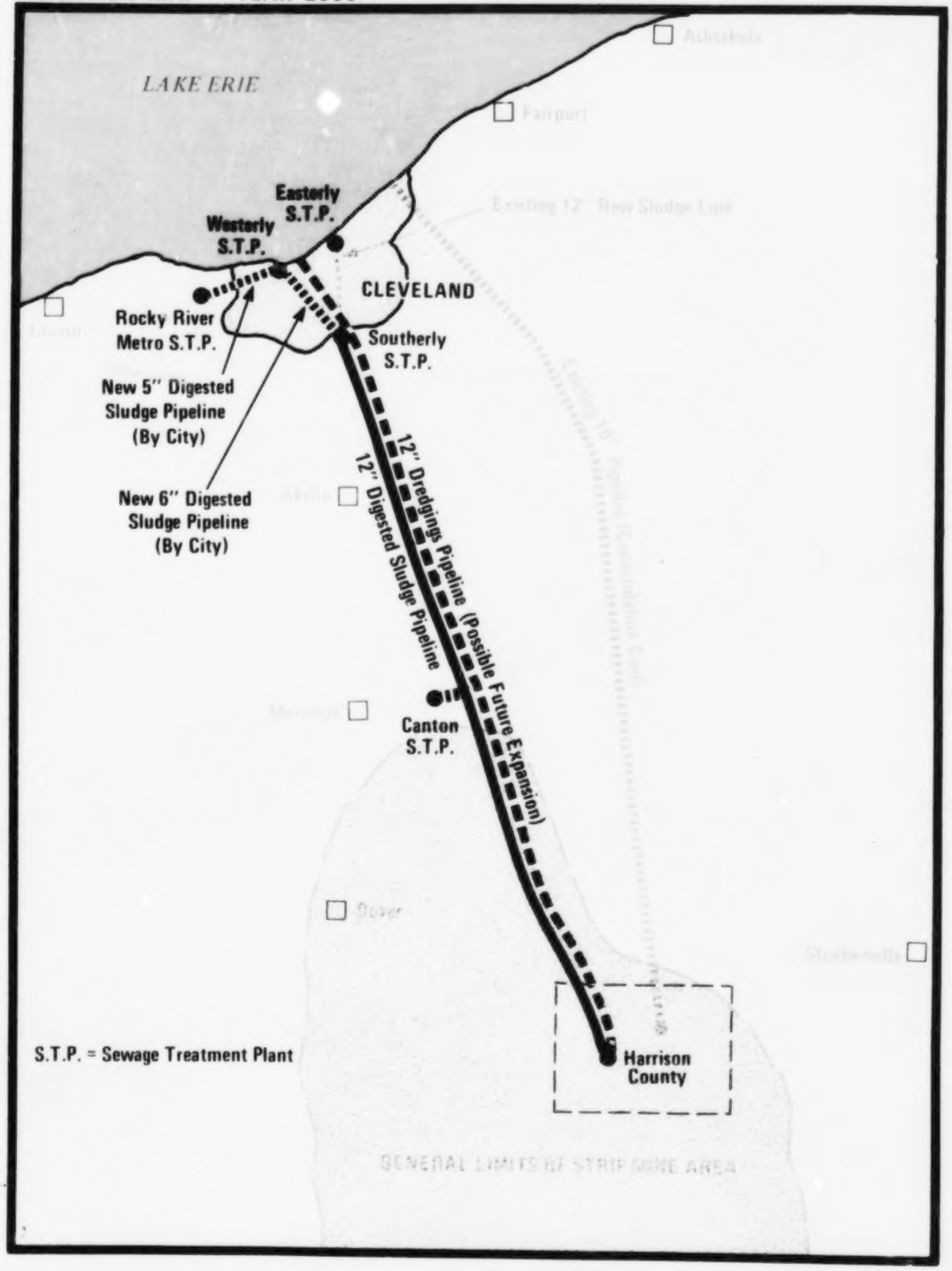
area through the year 2000, is presented in Figure 2. The system is based upon expansion of an initial 2-year demonstration program system to pick up additional sources of waste materials. In addition to the sludge disposal system, it includes a parallel 12-inch diameter pipeline system for the transportation of maintenance dredgings. With escalation to 1971, the estimated capital cost of the sludge disposal portion of the ultimate system is $14.8 million. The disposal costs, including collection, average $25 per ton over a 29-year period (1972-2000). This is compared with costs of $30 to $42 per ton by the most widely used in-plant disposal methods (see Table 1). The extension of the system to full regional capacity is dependent upon the implementation of the Metro Sewer Plan proposed by the F. W. P. C. A. in the "Lake Erie Report". (2) For the dredgings disposal system, the estimated capital cost is $10,300,000 and the estimated total disposal cost is $4.32 per ton of solids. The cost by present methods ranges from $1.33 to $3.22 per ton. Therefore the dredging system can only be justified on the basis of other benefits to society, since the dredgings, under the proposed system, would be treated prior to disposal.

3. The Demonstration Project. It is deemed that the cost/benefit ratio and the higher degree of pollution control provided by a regional waste management system warrant the immediate undertaking of a demonstration project to further validate the concept. The basic facility for the recommended demonstration project is summarized in Figure 3 and includes the transportation of digested sludge from Cleveland as a 3.5% slurry by a 93-mile, 12-inch diameter pipeline for disposal in strip mine land in Southern Ohio. In the demonstration project, sludge will be disposed of by a lagooning system. An experimental program of land irrigation will be carried on at the

F.

LAND D

LOCATION MAP – YEAR 2000


LAKE ERIE
Ashtabula
Fairport
Existing 12" Raw Sludge Line
Easterly S.T.P.
Westerly S.T.P.
CLEVELAND
Lorain
Rocky River Metro S.T.P.
Southerly S.T.P.
New 5" Digested Sludge Pipeline (By City)
New 6" Digested Sludge Pipeline (By City)
Akron
12" Dredgings Pipeline (Possible Future Expansion)
12" Digested Sludge Pipeline
Massillon
Canton S.T.P.
Dover
Steubenville
Harrison County
S.T.P. = Sewage Treatment Plant
GENERAL LIMITS OF STRIP MINE AREA

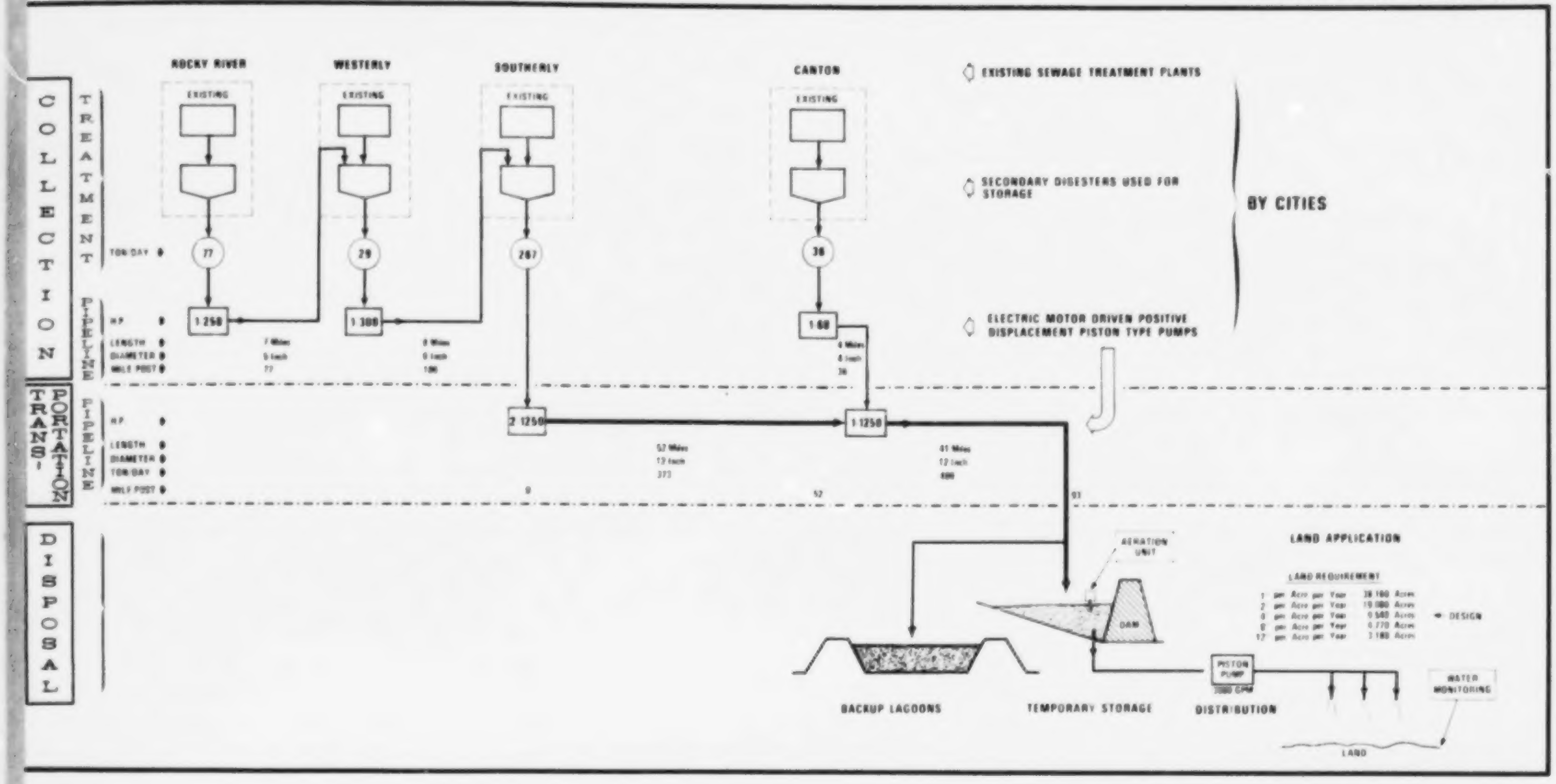
A

N.P.C.A. Waste Management Study

Figure 2

SPOSAL SYSTEM SUMMARY
DIGESTED SLUDGE

FACILITIES DIAGRAM


COLLECTION
TREATMENT
PIPELINE
TRANSPORTATION
PIPELINE
DISPOSAL
ROCKY RIVER
WESTERLY
SOUTHERLY
CANTON
EXISTING
TON/DAY
77
29
287
38
HP
LENGTH
DIAMETER
MILE POST
1 250
1 300
1 60
7 Miles
5 Inch
77
8 Miles
6 Inch
4 Miles
6 Inch
38
2 1250
1 1250
TON/DAY
52 Miles
12 Inch
373
41 Miles
12 Inch
0
52
93
EXISTING SEWAGE TREATMENT PLANTS
SECONDARY DIGESTERS USED FOR STORAGE
ELECTRIC MOTOR DRIVEN POSITIVE DISPLACEMENT PISTON TYPE PUMPS
BY CITIES
AERATION UNIT
DAM
LAND APPLICATION
LAND REQUIREMENT
1 per Acre per Year 38 160 Acres
2 per Acre per Year 19 080 Acres
4 per Acre per Year 9 540 Acres
8 per Acre per Year 4 770 Acres
12 per Acre per Year 3 180 Acres
DESIGN
PISTON PUMP
3000 GPM
WATER MONITORING
BACKUP LAGOONS
TEMPORARY STORAGE
DISTRIBUTION
LAND

COST BENEFITS

ECONOMIC BENEFIT

	Present Worth of Capital and Operating Costs @ 6% Years 1974 to 2000 (millions of dollars)
Present Method - Incineration	$36.2
● excludes capital cost of existing facilities but includes cost of new facilities	
● assumes capture of all solids from digester	
Proposed Regional Land Disposal System	31.9
● 12 inch pipeline system	
● Including cost of collection system provided by cities	
● No credit taken for land up grading	
Economic Benefit (difference)	$4.3

ENVIRONMENTAL BENEFITS

- Regional solution to sewage sludge disposal problem
- Potential improvement of disposal lands
- Reduction in region's air pollution
- Complete solids capture from digesters - eliminating significant loss of solids from sewage plants into Cuyahoga River and Lake Erie
- Complete nutrient removal from digesters

COSTS

CAPITAL COSTS

		Costs * (millions of dollars)
Original Installation: Demonstration System (ex development costs)		$9.1
Additions		
Collection & Transportation	1.0	
Land Distribution	4.7	
		5.7
Total Capital Costs		$14.8

ANNUAL COSTS

Transport and Disposal	Avg.	1974	2000
		Costs (millions of dollars)	
Direct Operating Costs	$1.49	$0.60	$1.74
Capital Charges @ 7.8%	0.94	0.71	0.19
Total Annual Costs	$2.43	$1.31	$1.93
Tons Transported (dry solids)	103,800	46,700	149,300
Unit Costs in $/Ton	$23.18	$27.97	$12.94
Collection (By Cities)	1.90	1.52	1.28
Total Unit Costs in $/Ton	$25.08	$29.49	$14.22

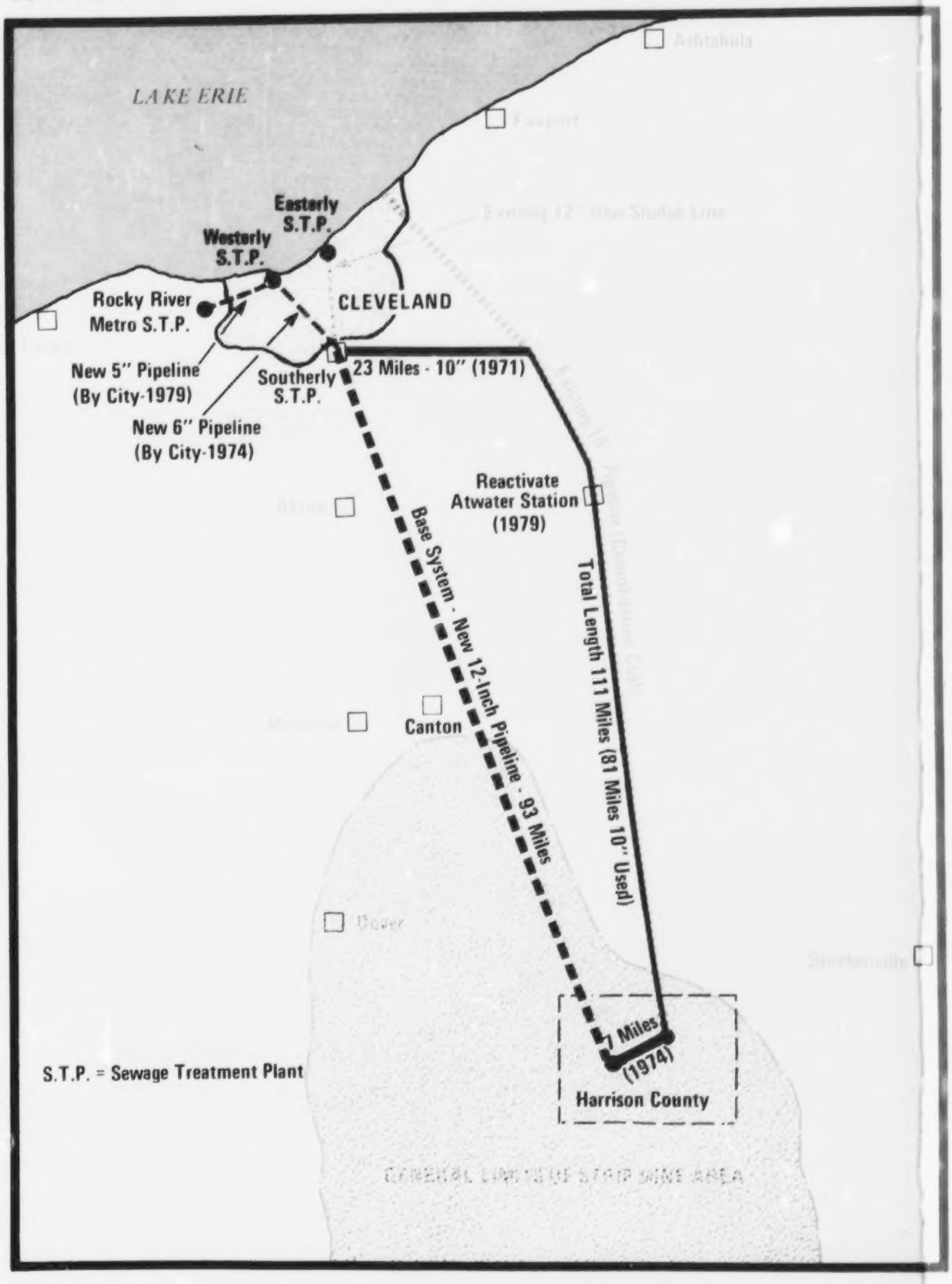
*1971 Dollars

B

F.W.P.C.A. V

DEMONSTRATION PROJECT FOR N
DIGES

LOCATION MAP



Ashtabula
LAKE ERIE
Fairport
Existing 12" Raw Sludge Line
Easterly S.T.P.
Westerly S.T.P.
Rocky River Metro S.T.P.
CLEVELAND
New 5" Pipeline (By City-1979)
Southerly S.T.P.
23 Miles - 10" (1971)
New 6" Pipeline (By City-1974)
Reactivate Atwater Station (1979)
Akron
Base System - New 12-Inch Pipeline - 93 Miles
Total Length 111 Miles (81 Miles 10" Used)
Canton
Dover
Steubenville
7 Miles (1974)
Harrison County
S.T.P. = Sewage Treatment Plant
GENERAL LIMITS OF STRIP MINE AREA

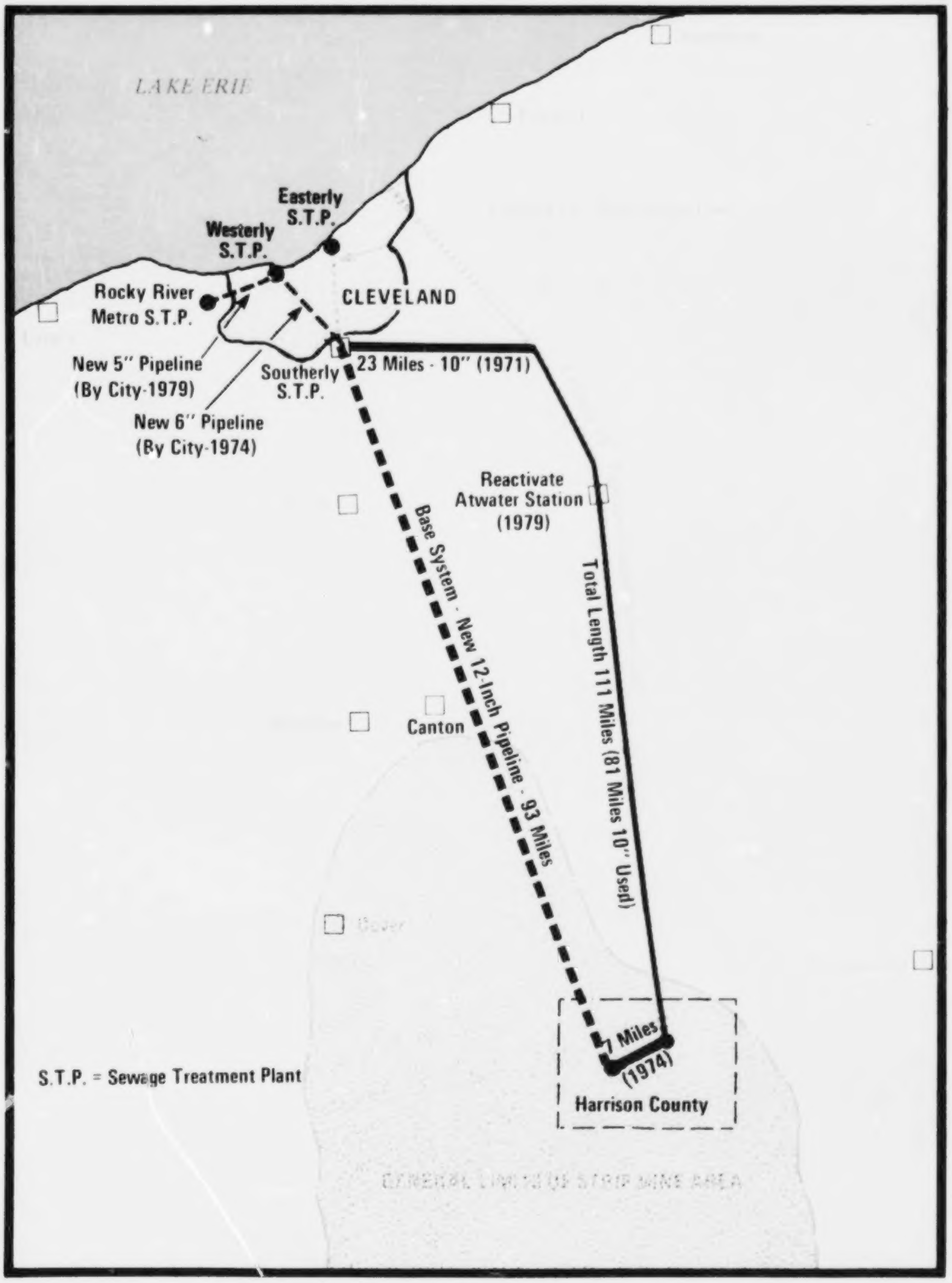
(7)

A

F.W.P.C.A. Wa

DEMONSTRATION PROJECT FOR NO
DIGEST

LOCATION MAP


LAKE ERIE
Easterly S.T.P.
Westerly S.T.P.
Rocky River Metro S.T.P.
CLEVELAND
New 5" Pipeline (By City-1979)
New 6" Pipeline (By City-1974)
Southerly S.T.P.
23 Miles - 10" (1971)
Reactivate Atwater Station (1979)
Base System - New 12-Inch Pipeline - 93 Miles
Total Length 111 Miles (81 Miles 10" Used)
Canton
Dover
7 Miles (1974)
Harrison County
S.T.P. = Sewage Treatment Plant
GENERAL LIMITS OF STRIP MINE AREA

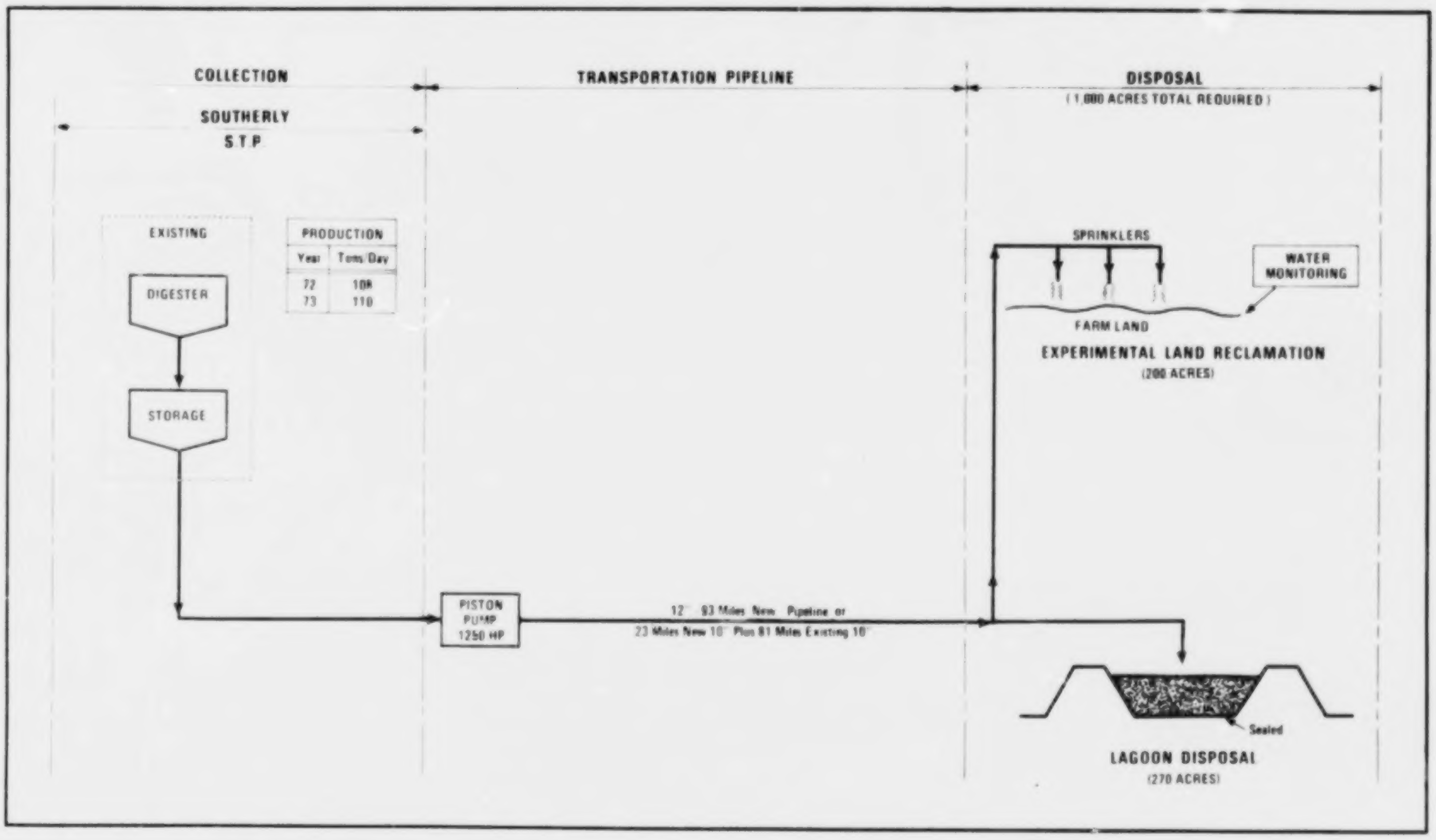
A

Figure 3

W.P.C.A. Waste Management Study

FOR NORTHEAST OHIO REGIONAL SYSTEM SUMMARY DIGESTED SLUDGE

GENERAL FACILITIES DIAGRAM


COLLECTION
TRANSPORTATION PIPELINE
DISPOSAL
(1,000 ACRES TOTAL REQUIRED)
SOUTHERLY
S.T.P.
EXISTING
DIGESTER
STORAGE
PRODUCTION
Year
Tons/Day
72
108
73
110
PISTON PUMP 1250 HP
12" 93 Miles New Pipeline or
23 Miles New 10" Plus 81 Miles Existing 10"
SPRINKLERS
WATER MONITORING
FARM LAND
EXPERIMENTAL LAND RECLAMATION
(200 ACRES)
Sealed
LAGOON DISPOSAL
(270 ACRES)

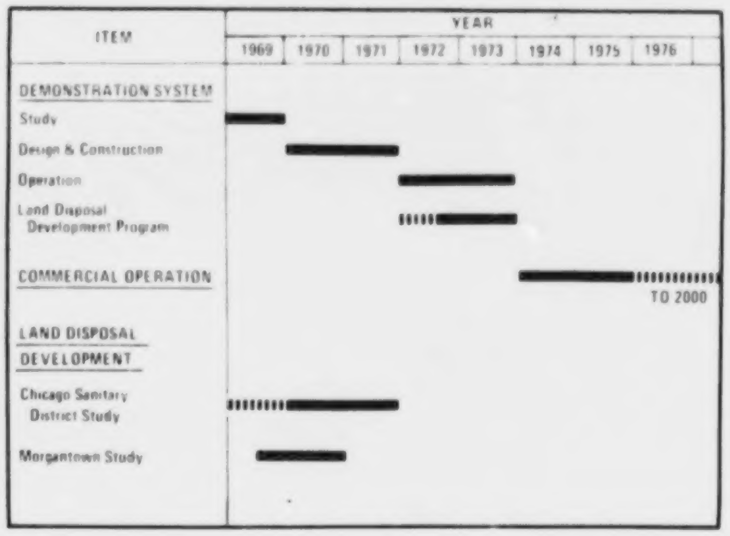
CAPITAL COST ESTIMATES

TOTAL COST FOR TWO YEAR DEMONSTRATION PROJECT

	COSTS*	
	NEW 12"	EXISTING 10"
CAPITAL COSTS:		
PIPELINES	$5,520,000	$1,620,000 ***
PUMP STATIONS	605,000	605,000
RIGHT-OF-WAY	1,100,000	400,000
LAGOON SYSTEM	1,875,000	1,875,000
TOTAL CAPITAL COSTS	9,100,000	4,500,000
TOTAL DIRECT OPERATING COSTS **	1,700,000	1,700,000
TOTAL DEMONSTRATION COSTS	$10,800,000	$6,200,000 ***

* 1971 Dollars
** Two Year Total
*** Excludes Payment for Existing 10" Line (To Be Made After Demonstration)

SCHEDULED ACTION



B

same time. This experimental work will verify the agricultural benefits of the regional concept of waste disposal, and will supplement and complement other field studies of sludge disposal. The demonstration project considers the transportation of the entire digested sludge production of the two largest treatment plants in Cleveland, which represent about 65 percent of the total production of digested sludge in the Northeast Ohio region. The project will prove the efficacy of the regional land disposal concept, define the costs, determine the public acceptance, establish environmental control procedures, and will be capable of expansion into the full regional system. The total cost of the demonstration project (including operating costs for 2 years) is $10.8 million. It is recommended that the demonstration be funded primarily by the federal government in cooperation with the State of Ohio. The institutional management considerations of the project are detailed in the body of the report.

However, Cleveland is in a unique position in that an unused 10-inch pipeline runs from a point east of the city to the disposal area. It is one of the reasons this region was chosen as a study area. As shown in Figure 3, this system could be utilized by constructing a new 23-mile 10-inch spur pipeline from Cleveland's Southerly Sewage Treatment Plant to the existing 10-inch pipeline. Eighty-one miles of the existing line could be used. Due to its small size, this system cannot handle the ultimate volume possible in the 12-inch case, but it very significantly reduces the initial risk capital required to demonstrate the concept; $6.2 million vs $10.8 million or $4.6 million less (see Figure 3). It is adequate to handle Cleveland's projected 1985 tonnages with an average cost in the order of $27/ton. Preliminary discussions with the present owners of this line, Consolidation Coal Company, indicate interest in either selling or leasing the line. It is recommended that this alternative be investigated further.

4. Ocean Disposal Concept. The specific area selected for evaluation of the merits of a regional waste disposal system involving ocean disposal was the Baltimore-Washington region. The digested sludge systems presented, capable of serving the needs of this region through the year 2000, are based upon pipeline collection with either ocean outfalls or sludge tankers utilized for disposal. The 80-mile outfall system is presented in Figure 4.

The proposed system accepts waste from 16 sewage treatment plants and collects and transports the waste to the disposal area by means of pipelines ranging from 4 to 18 inches in diameter. The system development consists of an initial phase, which will handle the major sludge sources in 1975 and a series of future system additions to pick up smaller plants as growth permits.

The estimated initial capital investment for the system is $50,440,000 and future additions will total $7,630,000. With escalation to 1971, the total capital investment is $61,600,000. The unit disposal costs for the period 1975 to 2000 will range from $55.00 to $23.10 per ton of dry solids, with an average cost of $27.80 per ton of dry solids.

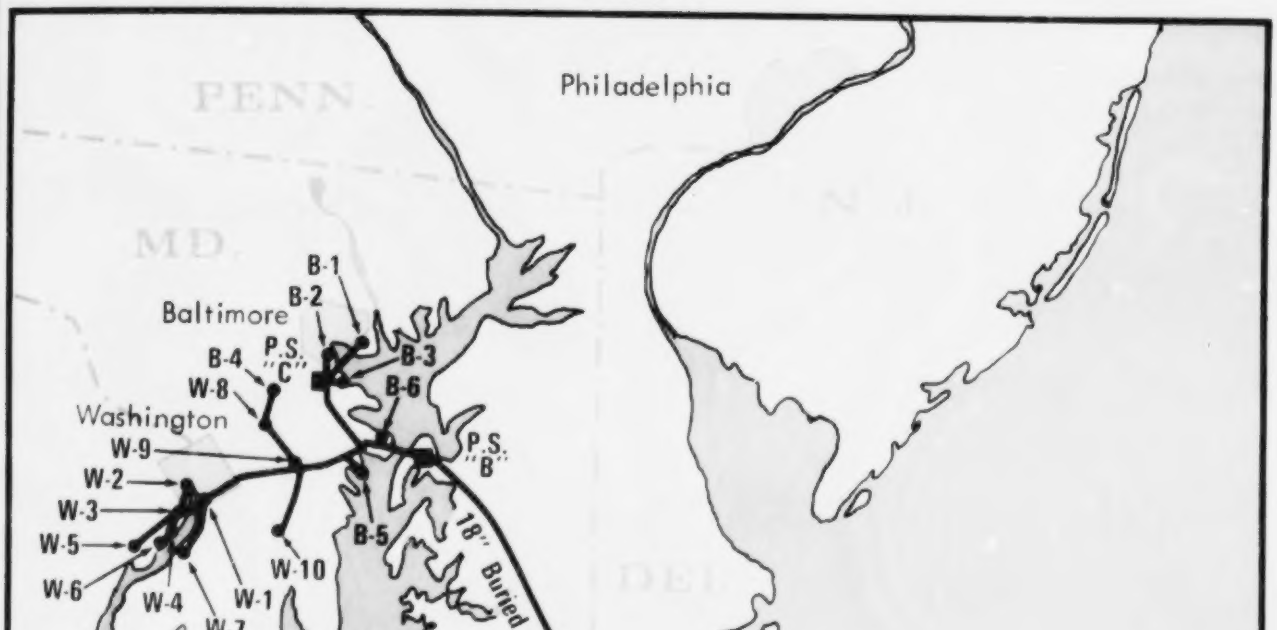
These disposal costs compare very favorably with costs projected for other disposal methods. For example, sludge incineration costs recently projected

F.W.P.C.A. Waste Management St

OCEAN DISPOSAL SYSTEM SUM

DIGESTED SLUDGE – 80 MILE OUT

LOCATION MAP – YEAR 2000


PENN
Philadelphia
MD
N J
Baltimore
Washington
B-1
B-2
B-3
B-4
B-6
B-5
P.S. "C"
P.S. "B"
W-8
W-9
W-2
W-3
W-5
W-6
W-4
W-7
W-1
W-10
18" Buried Pipeline
DEL
Pump Sta. "A"
18" – 80 Mi. Ocean Outfall
VA

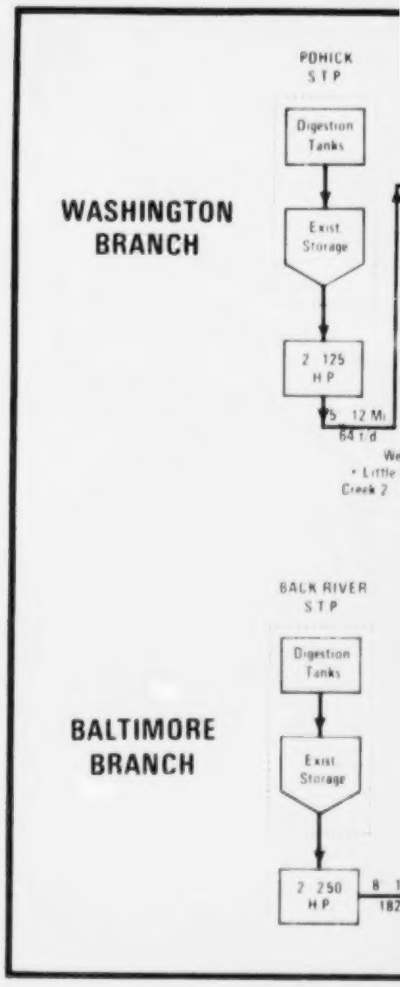
SEWAGE TREATMENT PLANTS

W - 1 DIST. OF COLUMBIA
W - 2 ARLINGTON
W - 3 ALEXANDRIA
W - 4 WESTCATE
W - 5 POHICK
W - 6 LITTLE HUNT. CREEK
W - 7 PISCATAWAY
W - 8 PARKWAY
W - 9 BELAIR–BOWIE
W - 10 WESTERN BRANCH

B - 1 BACK RIVER
B - 2 PATAPSCO
B - 3 COX CREEK
B - 4 SAVAGE
B - 5 ANNAPOLIS
B - 6 BROADNECK

(15)

A


WASHINGTON BRANCH
POHICK STP
Digestion Tanks
Exist Storage
2 125 HP
5 12 Mi
64 t/d
We
• Little
Creek 2
BALTIMORE BRANCH
BACK RIVER STP
Digestion Tanks
Exist Storage
2 250 HP
8 1
182

COST BEN

ECONOMIC BENEFIT

Present Methods:

- Assumes Average Cost of $40 /t
- Assumes Capture of all Solids fro

Proposed Regional Ocean Disposal S

Economic Benefit (d

Environmental Benefits :

- Regional Solution to Sewage Slud
- Reduction in Region's Air Poll
- Complete Solids Capture from Di
- Complete Nutrient Removal from

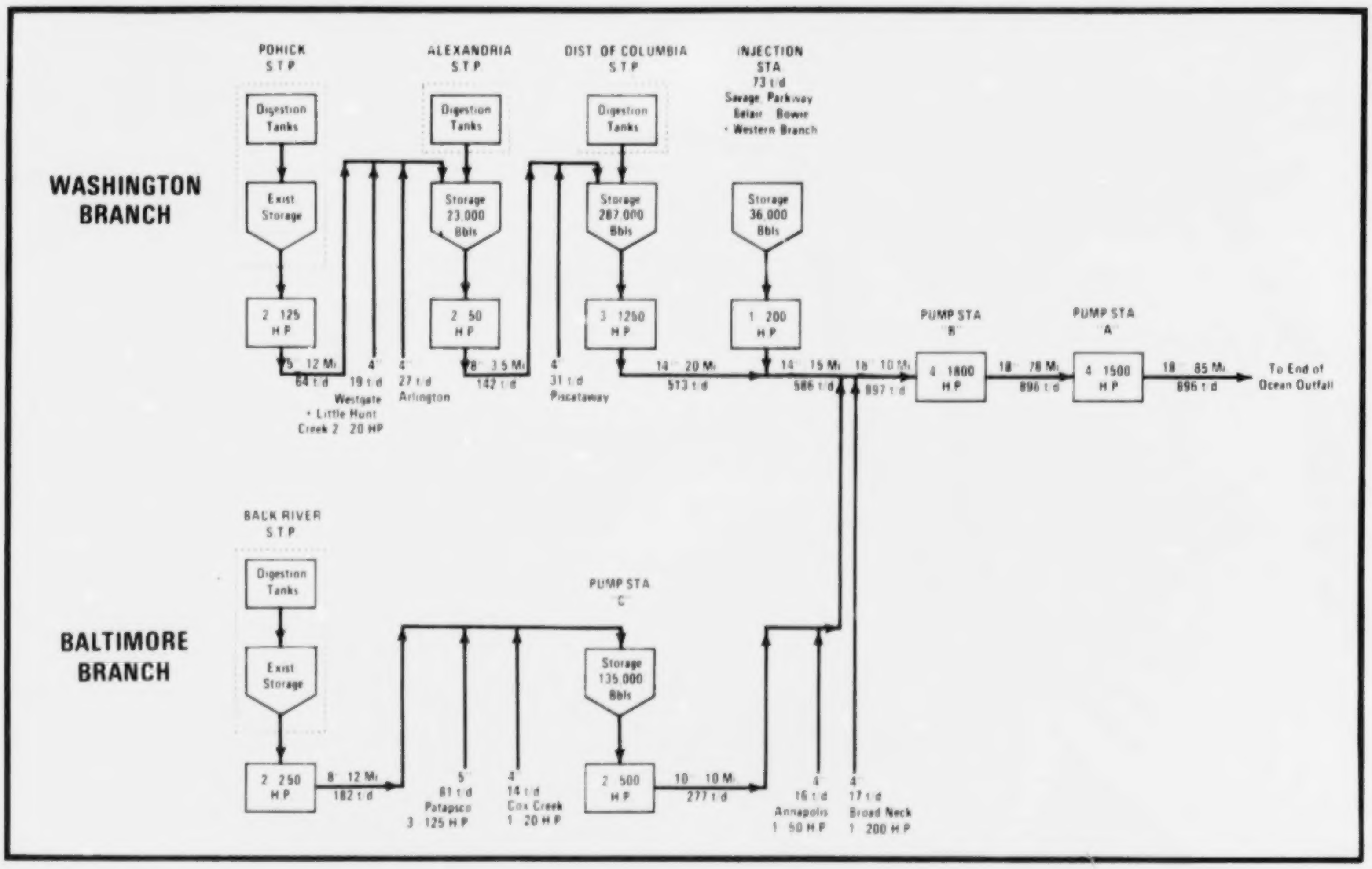
* 1971 Dollars

.P.C.A. Waste Management Study

Figure 4

DISPOSAL SYSTEM SUMMARY
SLUDGE – 80 MILE OUTFALL CASE

FACILITIES DIAGRAM


WASHINGTON BRANCH
POHICK S.T.P.
Digestion Tanks
Exist Storage
2 125 H.P.
5" 12 Mi
64 t/d
4" 19 t/d
Westgate + Little Hunt Creek 2 20 HP
4" 27 t/d
Arlington
ALEXANDRIA S.T.P.
Digestion Tanks
Storage 23,000 Bbls
2 50 H.P.
8" 3.5 Mi
142 t/d
4" 31 t/d
Piscataway
DIST. OF COLUMBIA S.T.P.
Digestion Tanks
Storage 287,000 Bbls
3 1250 H.P.
14" 20 Mi
513 t/d
INJECTION STA
73 t/d
Savage, Parkway Belair, Bowie + Western Branch
Storage 36,000 Bbls
1 200 H.P.
14" 15 Mi
586 t/d
18" 10 Mi
897 t/d
PUMP STA "B"
4 1800 H.P.
18" 78 Mi
896 t/d
PUMP STA "A"
4 1500 H.P.
18" 85 Mi
896 t/d
To End of Ocean Outfall
BALTIMORE BRANCH
BACK RIVER S.T.P.
Digestion Tanks
Exist Storage
2 250 H.P.
8" 12 Mi
182 t/d
5" 81 t/d
Patapsco
3 125 H.P.
4" 14 t/d
Cox Creek
1 20 H.P.
PUMP STA "C"
Storage 135,000 Bbls
2 500 H.P.
10" 10 Mi
277 t/d
4" 16 t/d
Annapolis
1 50 H.P.
4" 17 t/d
Broad Neck
1 200 H.P.

COST BENEFITS

ECONOMIC BENEFIT	Present Worth of Capital & Operating Costs @ 6% Years 1975 to 2000 * (Millions of Dollars)
Present Methods:	$103.0
• Assumes Average Cost of $40 /ton	
• Assumes Capture of all Solids from Digester	
Proposed Regional Ocean Disposal System:	81.5
Economic Benefit (difference)	$21.5

Environmental Benefits:
- Regional Solution to Sewage Sludge Problem
- Reduction in Region's Air Pollution
- Complete Solids Capture from Digesters
- Complete Nutrient Removal from Digesters

* 1971 Dollars

COSTS

CAPITAL COSTS	Costs (Millions of Dollars)*
Original Installation: 1974	$53.5
Additions in Later Years	8.1
Total Capital Costs	$61.6

ANNUAL COSTS	AVERAGE	1975	2000
Direct Operating Costs	$2.02	$1.39	$2.72
Capital Charges @7.82%	4.32	4.19	4.83
Total Annual Costs	$6.34	$5.58	$7.55
Tons Transported /Year	228,000	101,500	327,000
Unit Costs in $/ton	$27.80	$55.00	$23.10

* 1971 Dollars

B

for Washington, D. C.(10) are in the range of $52 to $58 per ton of dry solids. In addition, the pipeline-ocean disposal system will prevent pollution of local waterways due to loss of solids and nutrient discharge.

The choice of a pipeline as the mode of transportation of sewage sludge to the ocean was based on an economic comparison between ocean-going tankers and pipelines. The distance of 80 miles for the outfall length was chosen because this corresponds to the approximate limit of the continental shelf (650 ft. depth of water). An examination of a 5-mile outfall system for sludge disposal shows that definite economic advantages result from the shorter transportation distance. However, the unknown factors relating to the potential effects on the marine ecology from disposal of large volumes of waste materials to the shallow waters of the continental shelf, precludes its recommendation as a large-scale regional waste disposal solution without further extensive development work. The deep-water (80 mile) disposal system is not subject to the same risk, since large volumes of water are available for dilution. However, should a deep-water disposal system be installed, adequate monitoring of the disposal environment should be maintained in order to insure there will be no deleterious effects. A major difficulty in this scheme is in relation to the institutional management considerations, since numerous cities, 2 states, the District of Columbia and the Federal Government will all be involved.

APPROACH

This study of waste management is directed towards investigation of an integrated regional waste collection, transportation, and disposal system for the waste materials under consideration. To achieve this objective, it is necessary to develop a concept by which such a regional area may be selected and defined and to consider alternatives for the various elements which might be employed to make up such a system. Further, it is necessary to evaluate the sources and types of waste materials, necessity for treatment of wastes, and the collection and transportation of these wastes to disposal areas. Appropriate methods of disposal must be selected which will not present hazards or disturb the ecology of the disposal area. Rather the method employed should contribute to the benefit or improvement of conditions in the disposal area, if possible.

It is the intent of this study to establish representative regional areas suitable for waste management, to evaluate alternative means of disposal and to develop waste collection and disposal concepts which are broadly applicable to other areas of the United States. For this study, two specific regions have been selected as covering the two major alternatives - an inland region for land disposal and a coastal region for ocean disposal; land disposal is, of course, an option for the coastal region as well. The findings are developed to the point where the desirability of conducting further work, in the nature of pilot programs, can be assessed.

This study encompasses all aspects of a regional waste management system. Full consideration is given to the findings of other studies and an attempt is made to limit duplication of effort in those fields where other development work is being conducted under Federal contract. Development research work has been conducted in this study to verify the feasibility and establish the costs of pipeline transportation of waste materials in slurry form.

Pertinent data sources employed in the study and the methodology of selection of a waste disposal region are broadly presented in the following text.

METHODOLOGY OF STUDY

The growth in pollution and the rising costs of pollution control provide clear proof that a regional waste management program is now required since the smaller municipalities and disposal districts lack the capital, technical capability, and overall authority to effectively act on such problems.

The methodology pertaining to the selection of a waste management region and the evaluation of a waste management system, is presented in Figure 5. The intent of Figure 5 is to indicate the principal elements which must be evaluated and to present the interrelationship between these elements.

A regional waste management system should be considered when pollution exists within the area and there are large volumes of waste material. Such a waste management region should be related in part as a drainage basin, should be large enough to encompass unfragmented unit processes, should include an area suitable for long-term reception of the wastes, should provide for control of pollution, and should have economics that will support its installation and operation. This means that the wastes selected for disposal must have identifiable disposal costs

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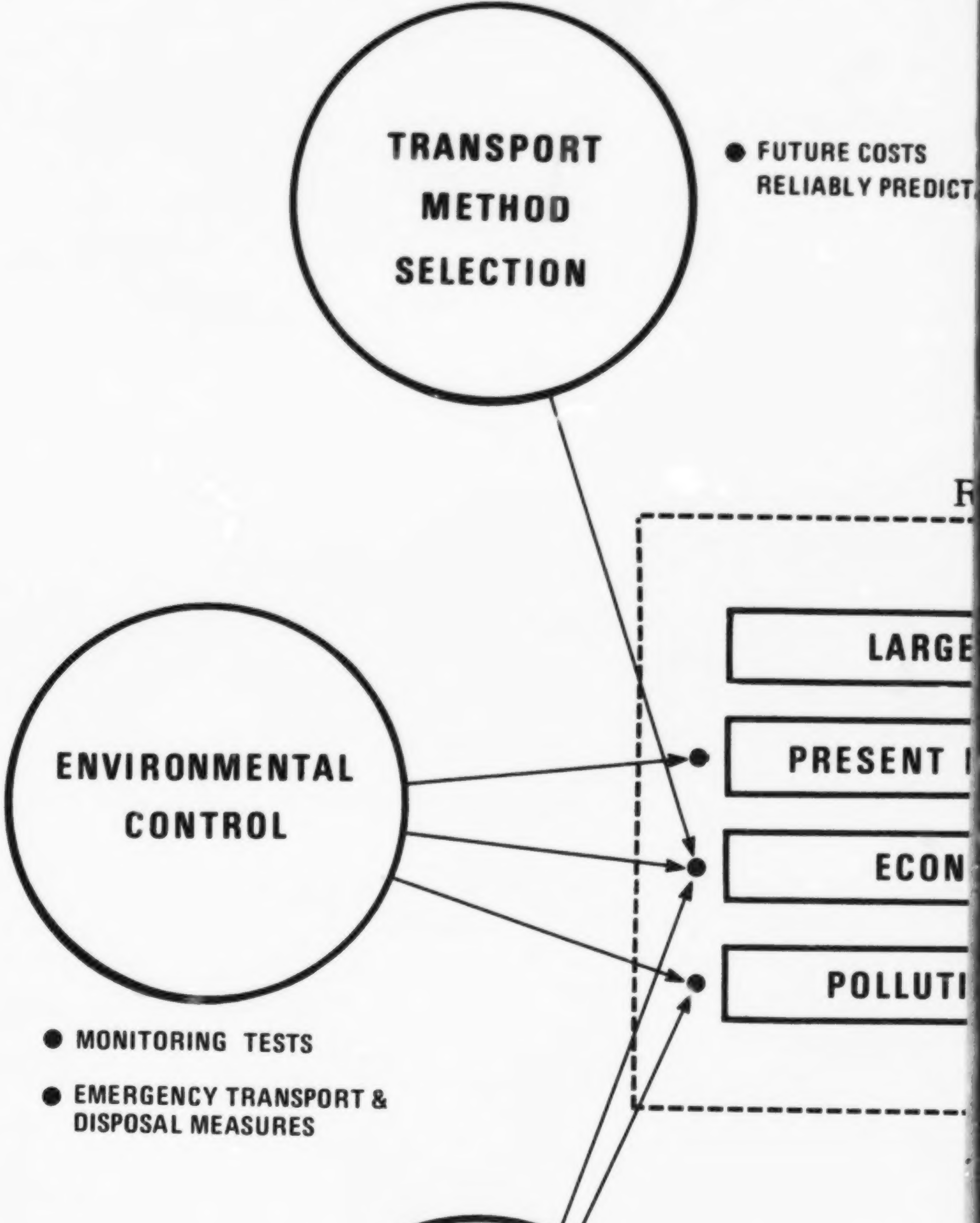
METHODOLOGY OF REGION SELEC


TRANSPORT METHOD SELECTION
● FUTURE COSTS RELIABLY PREDICT
R
LARGE
PRESENT
ECON
POLLUTI
ENVIRONMENTAL CONTROL
● MONITORING TESTS
● EMERGENCY TRANSPORT & DISPOSAL MEASURES
DISPOSAL METHOD SELECTION
● FUTURE COSTS RELIABLY PREDICTABLE

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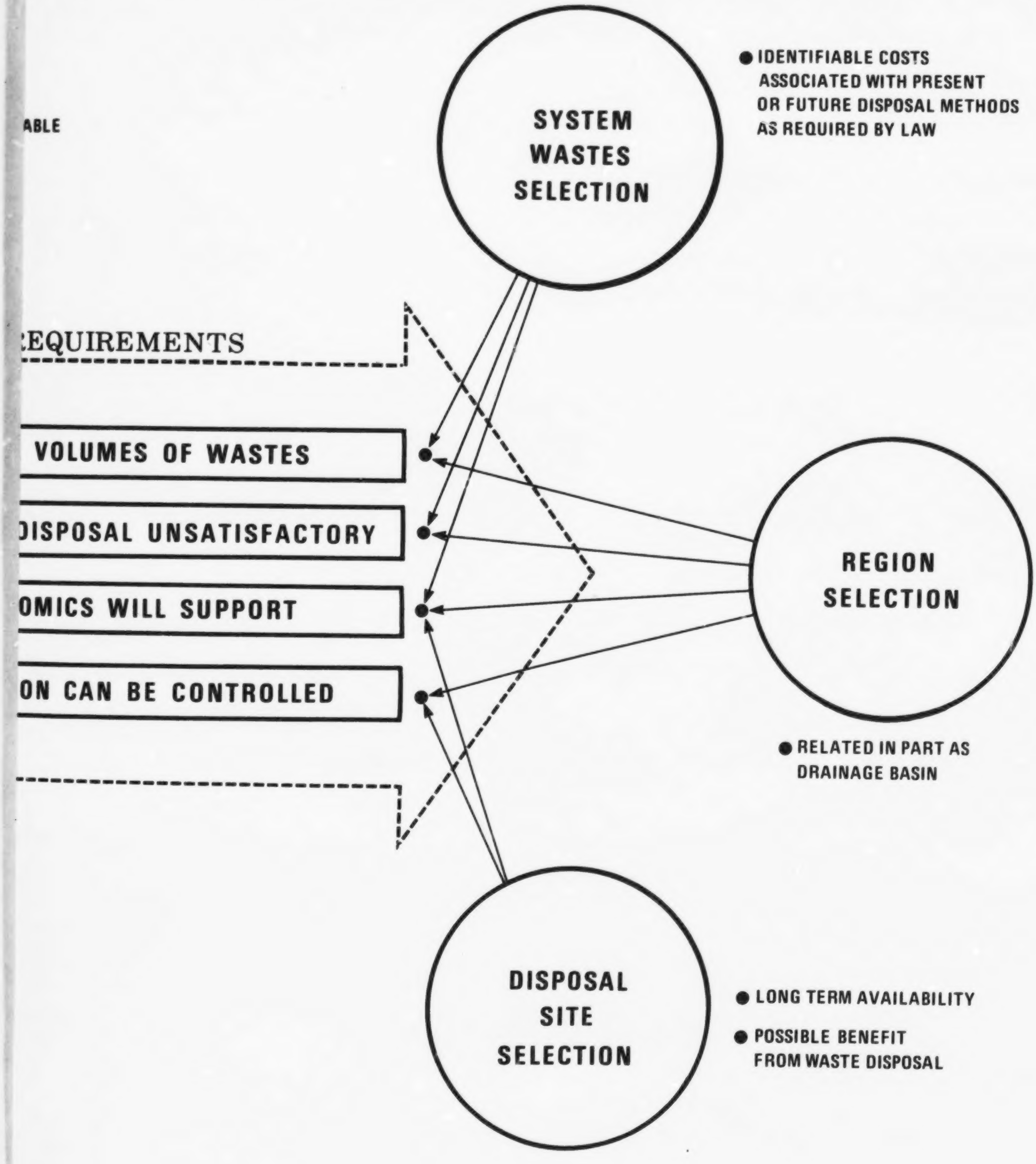
.W.P.C.A. Waste Management Study

Figure 5

TION & EVALUATION OF WASTE MANAGEMENT SYSTEM


SYSTEM WASTES SELECTION
● IDENTIFIABLE COSTS ASSOCIATED WITH PRESENT OR FUTURE DISPOSAL METHODS AS REQUIRED BY LAW
ABLE
EQUIREMENTS
VOLUMES OF WASTES
ISPOSAL UNSATISFACTORY
OMICS WILL SUPPORT
ON CAN BE CONTROLLED
REGION SELECTION
● RELATED IN PART AS DRAINAGE BASIN
DISPOSAL SITE SELECTION
● LONG TERM AVAILABILITY
● POSSIBLE BENEFIT FROM WASTE DISPOSAL

B

associated with their present methods, or such future methods as may be required by law, that the methods of transport and disposal must have future costs which can be reliably predicted, the disposal site must have a long-term availability, and that the system must control pollution - considering the type of waste, disposal method employed, and the disposal site. Ecological monitoring and safeguards must also be provided to document the effectiveness of the program and to provide the regional environmental control for the types of wastes being handled. The solution clearly requires the application of a systems engineering approach to the interaction of the various components.

SUPPLEMENTARY DATA

Current Federal Projects

Some of the more pertinent current projects which have a direct bearing on this study are as follows:

Study	Comments
Metropolitan Sanitary District (3) of Greater Chicago Land Disposal (Continuation of prior Public Health Service study)	- 1.2 million dollar land disposal demonstration to be completed in 1972. - 1.0 million dollar smaller scale demonstration of land disposal (performed primarily by University of Illinois) to be completed in 1970.
Sandy Hook Marine Laboratory (Based on prior Smithsonian Institute's recommendations)	- 250 thousand dollar study for the Corps of Engineers on "The Effect of Offshore Waste Disposal Practices in the Marine Community", including a) Sewage Sludge b) Dredging Spoil c) Cellar Dirt and Building Rubble 2-year study to be completed November 1970.
Morgantown Sludge Transportation demonstration of strip mine disposal	Facilities have been constructed to demonstrate pipeline transport and land disposal for small

communities. 18-month demonstration to start late 1969.

Present Methods of Disposal

The work of R. S. Burd, "A Study of Sludge Handling "(4) presents a comprehensive review of the costs and methods presently employed for sludge disposal. These costs, together with data gathered from specific sewage treatment plants, are employed as a basis for determining the economic benefits of the regional waste disposal concept.

Present Municipal Waste Disposal. The problems of disposal of municipal waste materials are substantial because of the large volumes which must be handled, the relatively high unit costs of disposal, and the need for environmental control. Nearly all municipal sewage treatment plants represent a compromise between cost and optimum environmental control.

Major municipal wastewater treatment plants represent investments amounting to many millions of dollars. Although various processes may be employed, the resulting final waste product is usually a sludge of from 3 to 5 percent solids concentration by weight. For this study, the sludge has been assumed to be digested to eliminate objectionable characteristics.

Disposal by lagooning is typical for small plants. Large plants frequently reduce the sludge to a filter cake and, subsequently, incinerate the cake. However, in the latter process, various waste streams result after the digestion process. These may include digester supernatant, elutriate, and filtrate. The liquids are typically returned to the head end of the plant and recycled through the system. This recycle often produces severe operational problems and may result in substantial discharge of waste materials to the receiving water. Also, the ash left from incineration which is still 30 to 40 percent of the initial dry solids weight must be disposed of. Thus, a disposal system which would accept the full output of the digester would materially increase the effectiveness of pollution control by providing virtually complete recovery of all digester materials. In Cleveland's Southerly plant, for example, nearly one-half of the digester solids are lost with the supernatant.

Large amounts of money and effort are being spent to improve sewage treatment processes. Limitations on suitable methods of sludge disposal include lack of land in metropolitan districts, stringent air pollution requirements imposed upon waste disposal equipment, increasing volumes of waste materials, and imposition of higher environmental standards. Similar problems exist in the disposal of other wastes. The foregoing factors mean that current methods of disposal will become more expensive and, in many instances, will be inadequate to serve future requirements. An analysis of current sludge disposal method alternatives is presented in Table I - presenting advantages, disadvantages and average disposal costs. Costs of disposal are shown to range from $12 per ton (lagooning under favorable conditions) to $42 per ton (wet oxidation) but many areas have costs exceeding these values.

Dredging Wastes. Waste materials resulting from maintenance dredging activities in harbor and shipping channels performed by the Corps of Engineers are currently disposed of by dumping the

TABLE 1

F.W.P.C.A. Waste Managemen

CURRENT SLUDGE DISPOSAL

Process	Advantages	
1. Disposal to Land		
A. Lagooning	1. Simple 2. Relatively low cost unless long transport distances are required 3. Flexible-may be used as an interim solution	1. Larg 2. Pote 3. Pote is w
B. Landfilling dewatered sludge	1. Relatively small amount of material for disposal	1. Susc 2. Pote
C. Heat drying	1. Allows material to be reintroduced back into ecological cycle	1. Rela 2. Unr 3. Pote equi
D. Underground disposal	1. Potential low cost if existing cavity is available	1. Leg 2. Pote
2. Disposal to the Ocean	1. Relatively low cost if community is near sea coast	1. Lon 2. Pot is w 3. Pot
3. Disposal to the Atmosphere		
A. Incineration	1. Requires relatively little space 2. Process is suitable for disposal of screenings and skimmings	1. Rel 2. Pot 3. Rec 4. Rec
B. Wet oxidation	1. Requires relatively little space 2. Flexible - various degrees of oxidation possible	1. Rel 2. Pot 3. Re 4. Re

* Based on "A Study of Sludge Handling and Disposal" by R.S. Burd F.W.P.C.A., Publ. WP-20-4. Figures include all prior preparation costs such as dewatering, digestion, etc.

** Allowing $10 per ton for sale of sludge.

A

TABLE 1

F.W.P.C.A. Waste Management Study

CURRENT SLUDGE DISPOSAL PROCESSES

ages	Disadvantages	Average Capital and * Operating Costs ($/dry ton)
st unless long s are required sed as an	1. Large land area requirement 2. Potential ground water contamination 3. Potential odor proglems unless material is well stablized	12
mount of sal	1. Susceptible to adverse weather conditions 2. Potential ground water contamination	25
o be reintroduced cal cycle	1. Relatively expensive 2. Unreliable market for product 3. Potential odor problems unless deodorization equipment installed	40**
if existing cavity	1. Legally forbidden in some areas 2. Potential ground water contamination	Unknown
t if community	1. Long term effects are unknown 2. Potential nusiance conditions unless material . is well stabilized 3. Potential marine life contamination	12
little space for disposal of mmings	1. Relatively expensive 2. Potential air pollution problems 3. Requires disposal of ash 4. Requires skilled labor	30
little space degrees of	1. Relatively expensive 2. Potential air pollution problems 3. Requires disposal of ash 4. Requires skilled labor	42
urd		

B

solids into inland waters or the ocean and occasionally by ponding and using dredgings as fill. Where substantial discharge of municipal and industrial wastes into rivers and harbors has occurred, the material may be very polluted.

Fly Ash. Fly ash is a waste residue generated by coal-burning power plants, and it is finding increasing use in the manufacture of concrete and other structural products. However, significant volumes of ash must be disposed of as a waste material. Such disposal is frequently by land fill, although oceandumping is occasionally employed. Such disposal is not a significant national problem now, but it may pose difficulties in some metropolitan areas.

Water Treatment Sludge. Another waste material of lesser volume is water treatment plant sludge resulting from chemical coagulation. These sludges are now usually disposed of by discharging them back to the water source. Sometimes, the material is discharged to lagoons or to the sanitary sewer system which could cause an increase in costs of incineration or other treatment methods. This procedure, however, is ideal for inclusion of these sludges into a regional disposal system. Tonnages in this study do not include water treatment plant sludge, but inclusion would enhance the economics of the system.

LAND DISPOSAL - DEMONSTRATION PROJECT

SELECTION AND DESCRIPTION OF STUDY REGION

The Great Lakes Megalopolis area, as defined in this study is shown in Figure 1. This megalopolis occupies less than four percent of the total U. S. land area, yet it includes almost fifteen percent of the total population and accounts for one-third of the nation's industrial output. Included in this area are the metropolitan areas of Chicago, Detroit, Cleveland, Buffalo and Milwaukee, all of which have populations in excess of a million people and all of which are highly industrialized.

The combination of population and industrial concentration has made the problems of waste disposal and pollution in this area very severe. The quantities of wastes to be handled are huge, and the fact that the area contains such large numbers of people creates the need for high environmental standards, thus further sensitizing the situation.

As discussed previously, development of a waste management concept for this megalopolis requires detailed analysis of a specific region within the area which is representative of the whole area in terms of type and magnitude of waste handling problems.

The location chosen for specific case study of a regional land disposal system is the Northeast Ohio region. The region, of which Cleveland is the major center of population, is shown in Figure 6 . The factors which led to the selection of this region are as follows:

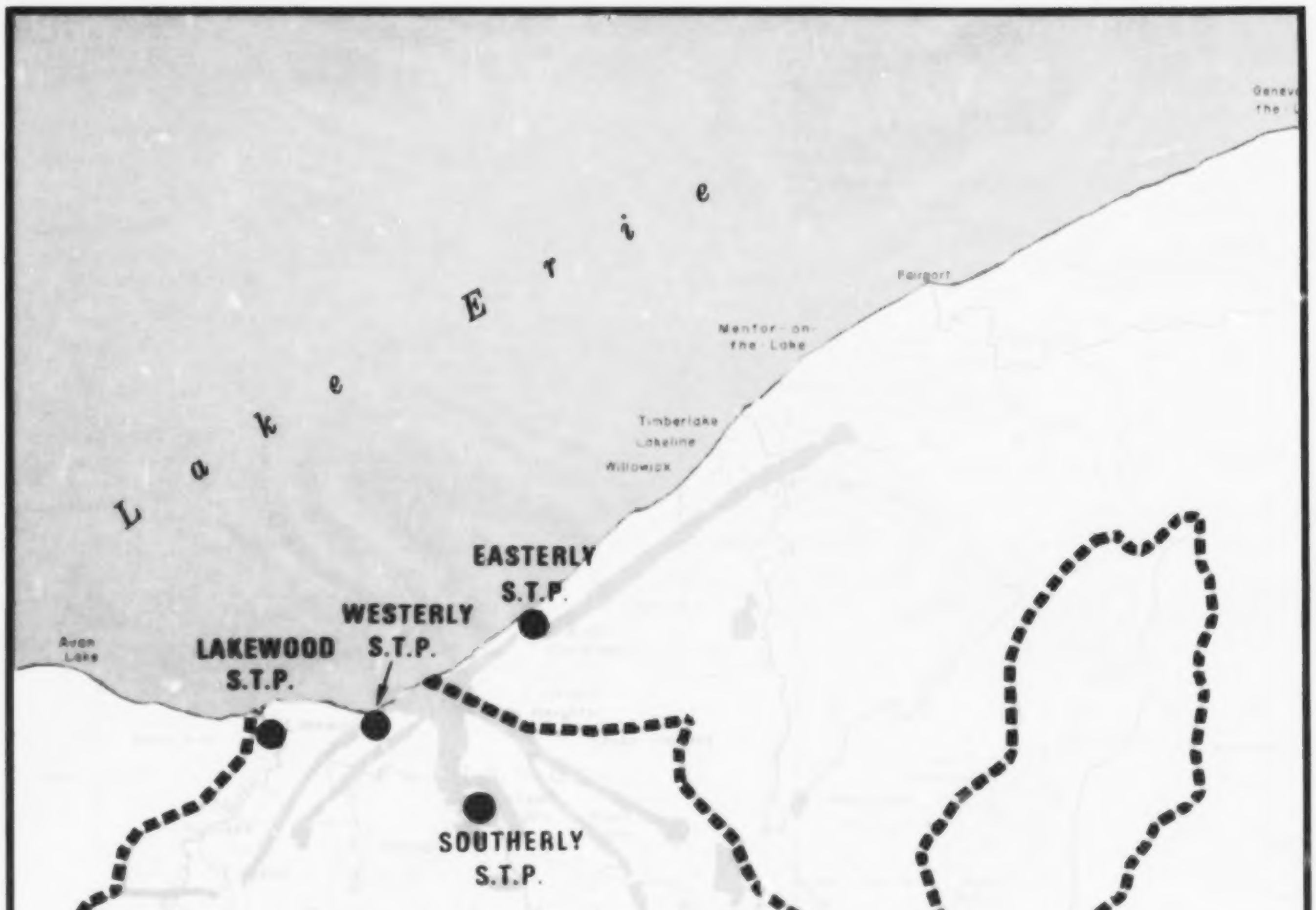
- There is a specific and severe waste disposal problem in this region as witnessed by the polluted condition of Lake Erie and the Cuyahoga River. (2) (5)
- The regional pollution problems are typical of those generally experienced in the Great Lakes megalopolis area.

Figure 6

F.W.P.C.A. Waste Management Study

GENERAL LOCATION MAP

NORTHEAST OHIO REGION


Lake Erie
Fairport
Mentor-on-the-Lake
Timberlake
Lakeline
Willowick
Avon Lake
EASTERLY S.T.P.
WESTERLY S.T.P.
LAKEWOOD S.T.P.
SOUTHERLY S.T.P.
MEDINA
AKRON S.T.P.
LIMIT OF CUYAHOGA & ROCKY RIVER DRAINAGE BASINS
GENERAL LAND USE: 1980
(From Figure 7 of Reference 13)

- The magnitude of the wastes considered is such that effective regional disposal could result in economies of scale, and would significantly aid pollution control in the area.
- The region contains land areas which are suitable as disposal sites. (Actual site selection is discussed in the next section).

Thus, the selected region is consistent with the criteria for selection demanded by the system methodology as discussed previously.

The wastes of particular interest to this study are digested sludge and maintenance dredgings. One source (2) states that a major source of pollution of Lake Erie is from municipal wastes, and the safe disposal of maintenance dredgings in this area is a subject of considerable current concern. The projected volumes of digested sludge from the major treatment plants in this region, up to the year 2000, are given in Table 2. A full discussion of the basis and method of projection of these volumes is given in Appendix B. Table 3 shows the annual volumes of maintenance dredgings removed from the Cuyahoga River and Cleveland Harbor. The maintenance dredging volumes are not expected to increase above the present level of operations, since it is unlikely that further deepening of harbors and connecting channels by new work dredging will occur in the near future. This is discussed in more detail in Volume II of this study.

TABLE 2

F. W. P. C. A. Waste Management Study
PROJECTED SLUDGE QUANTITIES
NORTHEAST OHIO REGION*

Dry Tons/Day

Plant	1970	1975	1980	1985	1990	1995	2000
Cleveland Southerly	102	116	159	207	232	249	267
Cleveland Westerly	10	16	21	26	28	29	29
Lakewood	4	5	24	41	61	69	77
Canton	14	15	21	27	30	33	36
Total	130	152	225	301	351	380	409
Akron	59	65	90	121	147	162	177

*Based on Metro System with chemical precipitation - includes both digested sludge and waste chemical sludge.

TABLE 3

F. W. P. C. A. Waste Management Study

PROJECTED DREDGING VOLUMES

NORTHEAST OHIO REGION

Location	Quantity cu. yds/year of inplace material	Tons of solids/year*
Cleveland Harbor	560, 000	350, 000
Cuyahoga River	720, 000	450, 000
	1, 280, 000	800, 000

* Based on 1250 lbs. solids per cubic yard of inplace material

GENERAL SCOPE OF DEMONSTRATION PROJECT

As stated previously, the intention of this study is to present, by detailed analysis of a specific region, a methodology which may be applied to regional waste management problems in general. In this section, the methodology has been applied to the Northeast Ohio region for a specific demonstration project that will safely and economically dispose of the various wastes under consideration during 1972 and 1973. In a subsequent section of this study, a regional disposal system to handle the waste volumes in the Northeast Ohio region for the year 2000 is presented. However, it is anticipated that the public acceptance of such a scheme, on either a local or national level, would require prior justification in the form of a successful large-scale demonstration even though the scheme is technically and economically viable.

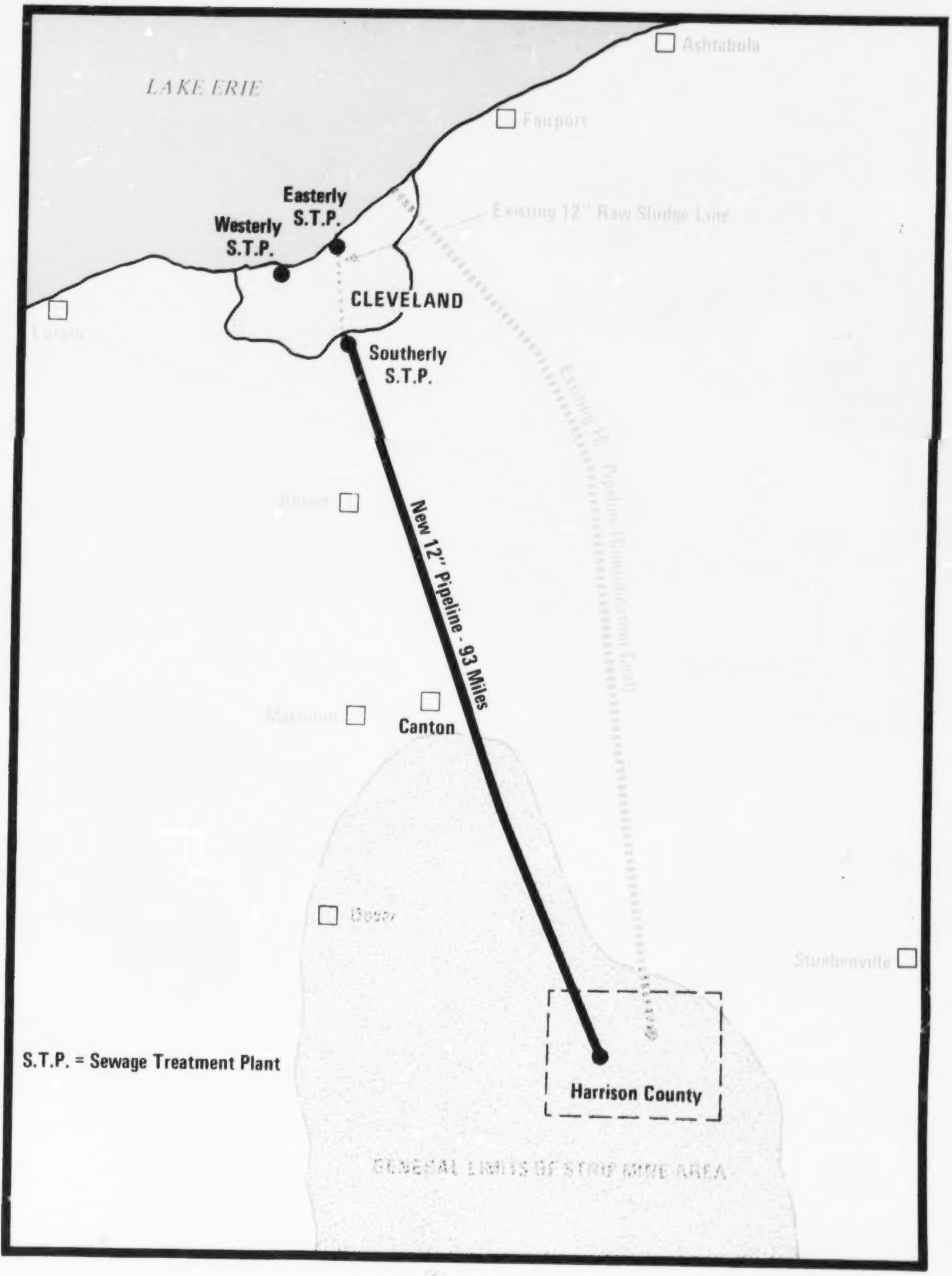
The system proposed to accomplish this is shown in Figure 7 and utilizes a new 12-inch pipeline system. Digested sludge from the Southerly sewage treatment plant in Cleveland will be transported via this pipeline to a disposal site about 93 miles to the south. For the demonstration, only sludge from Cleveland is considered.

The use of a pipeline - land disposal system for digested sludge is not a new concept for the City of Cleveland. In 1955, John J. Wirts, Superintendent of Cleveland's Easterly Sewage Treatment Plant, proposed that digested sludge be pumped to Southern Ohio for upgrading the disturbed strip mine lands.

Figure 7

F. W. P. C. A. WASTE MANAGEMENT STUDY

DEMONSTRATION SYSTEM


LAKE ERIE
Ashtabula
Fairport
Existing 12" Raw Sludge Line
Easterly S.T.P.
Westerly S.T.P.
CLEVELAND
Lorain
Southerly S.T.P.
Existing 10" Pipeline (Consolidation Coal)
Akron
New 12" Pipeline - 93 Miles
Massillon
Canton
Dover
Stuebenville
S.T.P. = Sewage Treatment Plant
Harrison County
GENERAL LIMITS OF STRIP MINE AREA

In a later section, an alternative demonstration system is presented. Cleveland is in the unique position of being in close proximity to an unused 10-inch pipeline running from just east of Cleveland to the Harrison county disposal area. (This is the retired Consolidation Coal slurry line). Use of this line, although it has a lower ultimate capacity than the 12-inch, could prove to be quite attractive since it could reduce the demonstration system capital costs from 9.1 to 4.5 million dollars. As a general solution, however, since virtually no other city would be in this unique position, the new 12-inch pipeline system is presented as the base case.

This new 12-inch system results in an average cost over the period from 1973 to 2000 of about $25 per ton of dry solids transported, including cost of collection and capital recovery. This is very attractive economically since as noted earlier, present sludge disposal costs for most cities average from $30 to $42 per ton (see Table 1). Furthermore, the Northeast Ohio region may be considered fairly representative since the population is not too large and the disposal area is a relatively long distance from the metropolitan area. Therefore, the costs presented should be achievable for many other areas. It should be noted that the $25 per ton excludes any land upgrading credit for resurfacing or for agricultural benefits of soil conditioning. This could be a major economic benefit, especially in the face of a rapidly rising national population.

The demonstration system will attempt to achieve the following objectives:

- To demonstrate that the regional system concept can be applied to solve specific waste disposal problems. The total digested sludge production of the City of Cleveland will be handled - this is equivalent to about 65 percent of the total Northeast Ohio region production. Since all sludge and supernatant would be removed, Cleveland's problem of significant losses of solids and nutrients to Lake Erie and the Cuyahoga River would be eliminated.
- To confirm projections of pilot plant work and to obtain commercial operating data which cannot be acquired by pilot or laboratory testing. The program will ensure that the design of future systems will be made with the full knowledge of the problems of handling large volumes of material.
- To refine the economics of the disposal system - obtain firm cost data on such aspects as the seasonal effects on operation which will be invaluable for the costing of future projects.
- To determine, in detail, what is required to ensure that the system is socially acceptable to meet all institutional and management problems in this field.

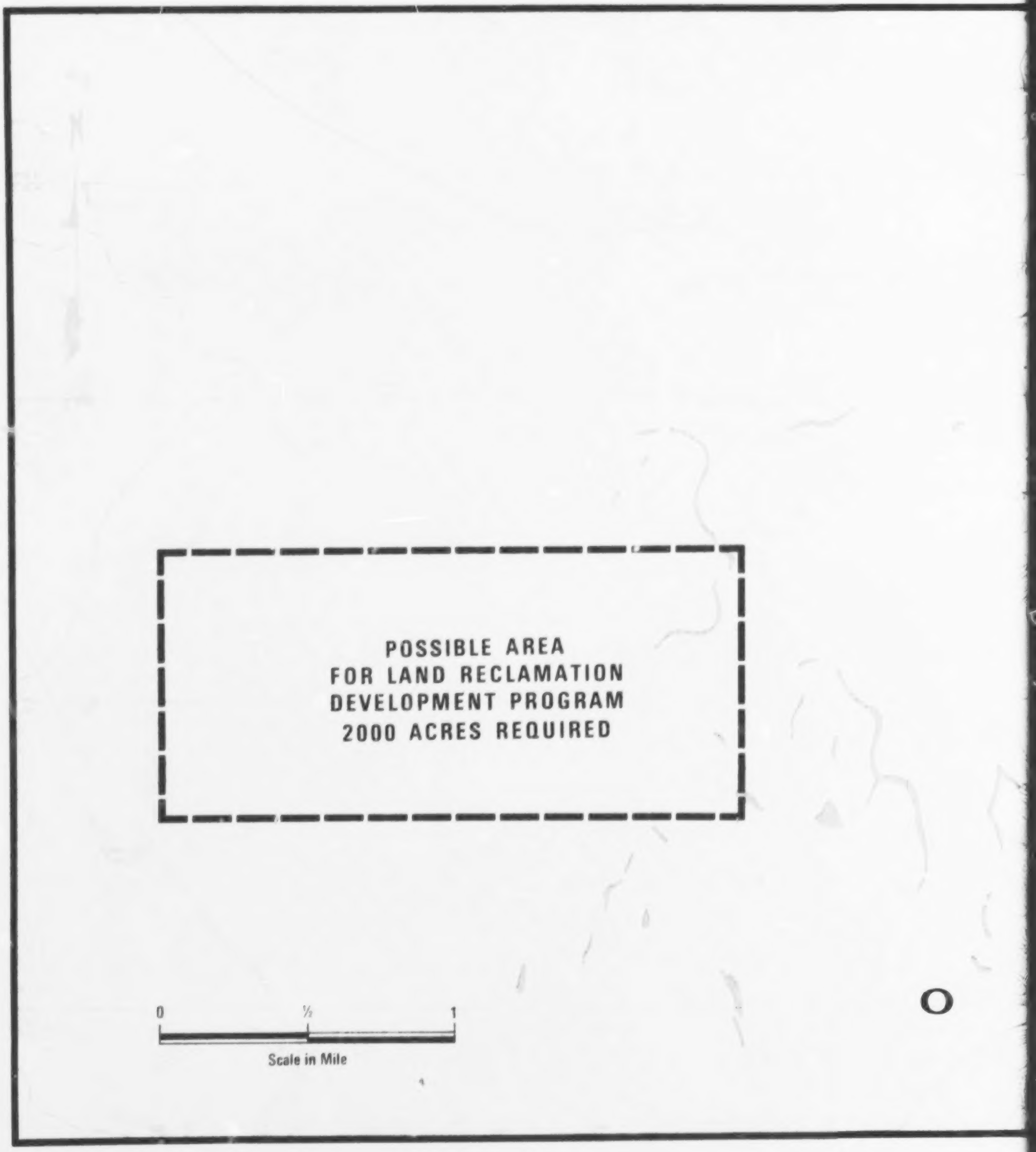
The disposal site chosen is located in Harrison County, Ohio. The choice of this site was made after considering farmland, marshland and strip-mine land as possible disposal sites. A potential specific plot for this purpose is shown in Figure 8.

Use of sewage sludge as a fertilizer for farm land in the area was rejected for this application primarily because of the uncertainties involved in the complex distribution and promotional system required to reach the required number of farmers.

In Ohio, various marsh areas have the capacity to hold the waste produced in the study area for many years. However, the disposal of wastes in such an area would constitute a transfer of pollution and would destroy the natural habitat of various forms of wildlife. Some of these

F.W.P.C.A. WASTE MAN

POSSIBLE LAND DISPOSAL SITE FO

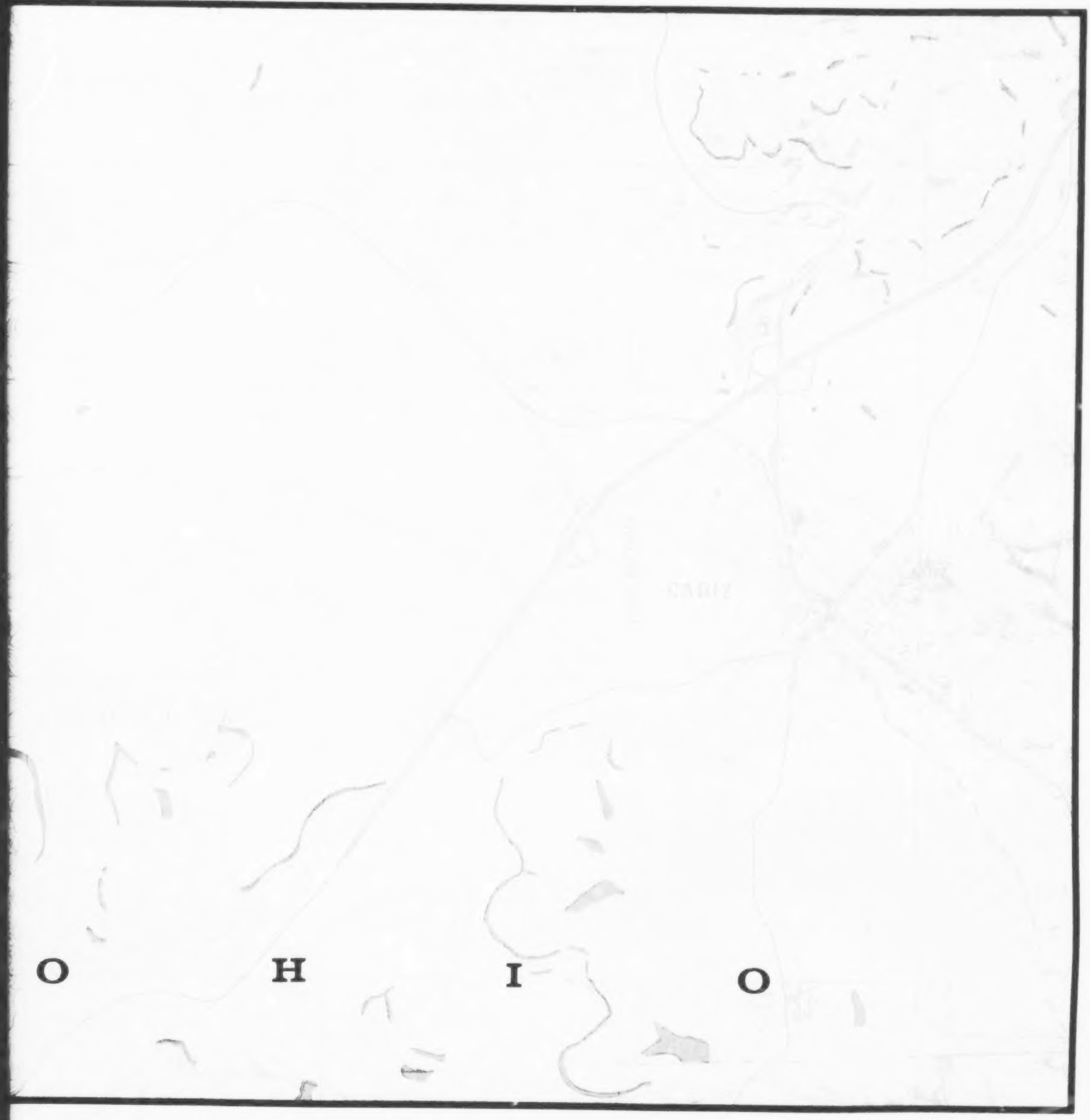

POSSIBLE AREA
FOR LAND RECLAMATION
DEVELOPMENT PROGRAM
2000 ACRES REQUIRED
0
½
1
Scale in Mile
O

A

WASTE MANAGEMENT STUDY

L SITE FOR TWO -YEAR DEMONSTRATION

Figure 8



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marshes are already protected areas, such as the Mentor Marsh near Cleveland.

The use of disturbed land remaining from the strip mining of coal is an ideal location for the disposal of wastes. In Southern Ohio, large areas of this type of land are available. Strip mine land could benefit in several ways from the application of waste materials. Firstly, the application of digested sewage sludge could be used to develop a good topsoil over wide areas, thus renovating the land for agricultural or recreational use. Secondly, maintenance dredgings can be used to fill the troughs, thus leveling the land. In addition, the application of alkaline fly ash and water treatment plant sludges would help reduce the acidity of the strip mine lands.

Figure 7 shows the bounds of possible strip mine disposal sites in the hinterland of Cleveland. These areas begin south of Canton (50 - 60 miles from Cleveland) and extend through Harrison County (110 - 120 miles from Cleveland). The use of the Harrison County lands is preferable at this time for the following reasons. The Harrison County region has much larger areas of contiguous strip mine land. In addition, the mining areas in Harrison County are operated by relatively few concerns, and negotiations to obtain adequate land would be greatly simplified. As will be shown later, transportation is not the major cost item in such systems; therefore, the additional distance can be tolerated. It is felt that the Harrison County disposal site best satisfies the social and economic criteria.

It is expected that the necessary disposal system operating experience would be obtained over an operating period of two years; 1972 and 1973. The demonstration system proposed is designed to accommodate expansion to the full Northeast Ohio regional system, which will take all the sludge produced in the region up to the year 2000. This aspect is discussed in detail in a later section.

DEMONSTRATION SYSTEM DESCRIPTION

This section is a description of the facilities required for the demonstration system. The description is separated into three elements; collection, transportation and land disposal. A flow sheet of the proposed demonstration facilities is shown in Figure 9.

Collection System

Raw sludge from Easterly has been pumped to Southerly for digestion since 1937 and this operation will continue during the demonstration system. For this reason, Southerly is the obvious focal point of any future collection system. For the demonstration project, only the sludge at Southerly will be transported. The average volume of digested sludge during the demonstration period amounts to 110 tons of solids per day.

The operation of the system will be greatly affected by decisions on future waste treatment practice. For example, the Southerly plant is faced with a number of severe operating problems. A recent report, "Master Plan for Pollution Abatement" (6) suggests specific programs towards solving these problems. It is assumed that, by the time the demonstration project is implemented, sufficient action will have been taken on the recommendations of this and other plans to ensure a digester output of 3.5 weight percent material to the transportation system.

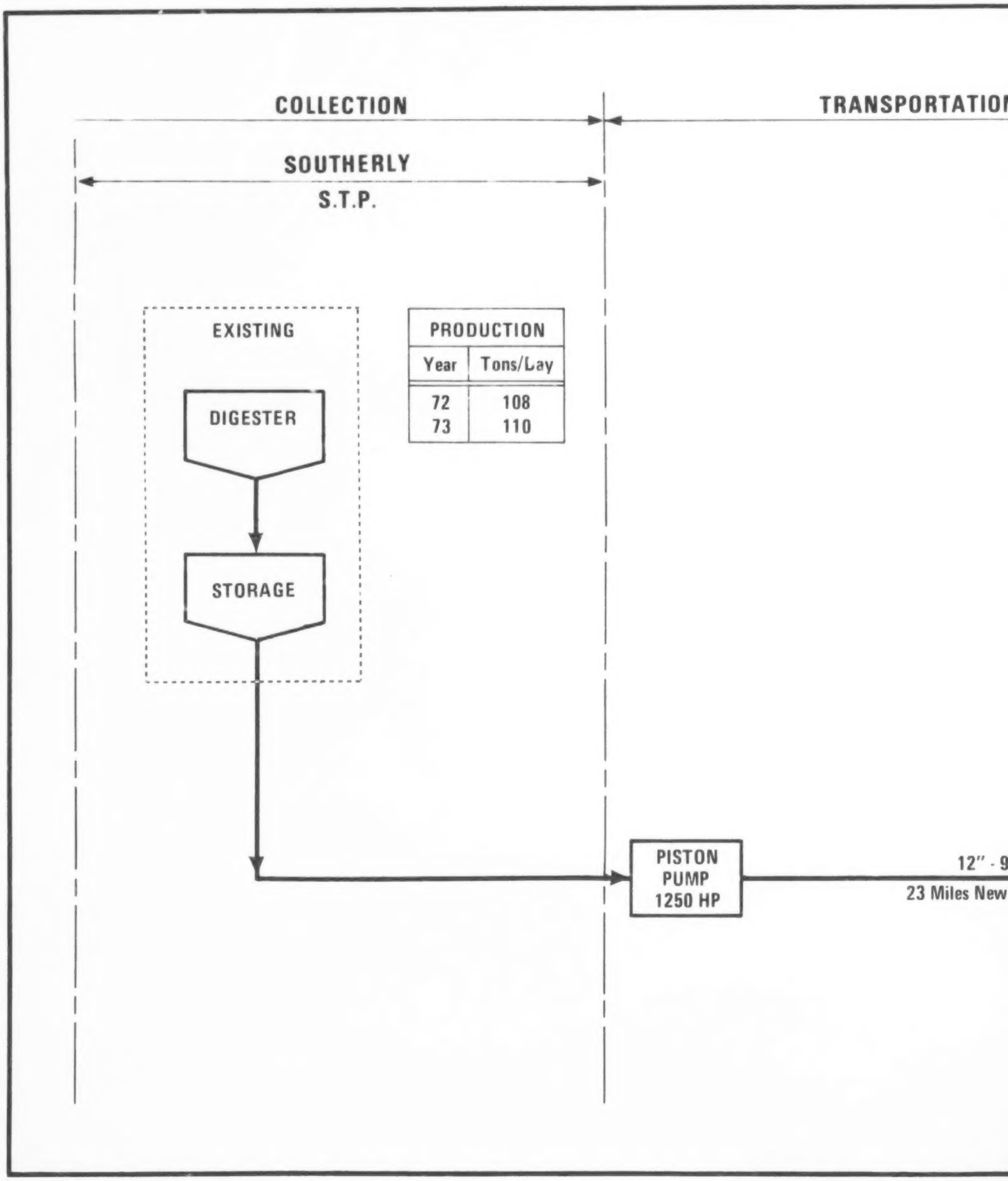
Transportation System

A study of the relative economics of using trucks, rail or pipeline to move digested sludge from Southerly to Harrison County has shown that pipeline is the most economic mode of transport. Figure 10 shows the bases and results of this comparison.

The economic advantage of using a pipeline rather than trucks or

F.W.P.C.A. Waste

FACILITIES SUMMARY OF DEMONSTRATI


COLLECTION
TRANSPORTATIO
SOUTHERLY
S.T.P.
EXISTING
DIGESTER
STORAGE
PISTON
PUMP
1250 HP
12" - 9
23 Miles New

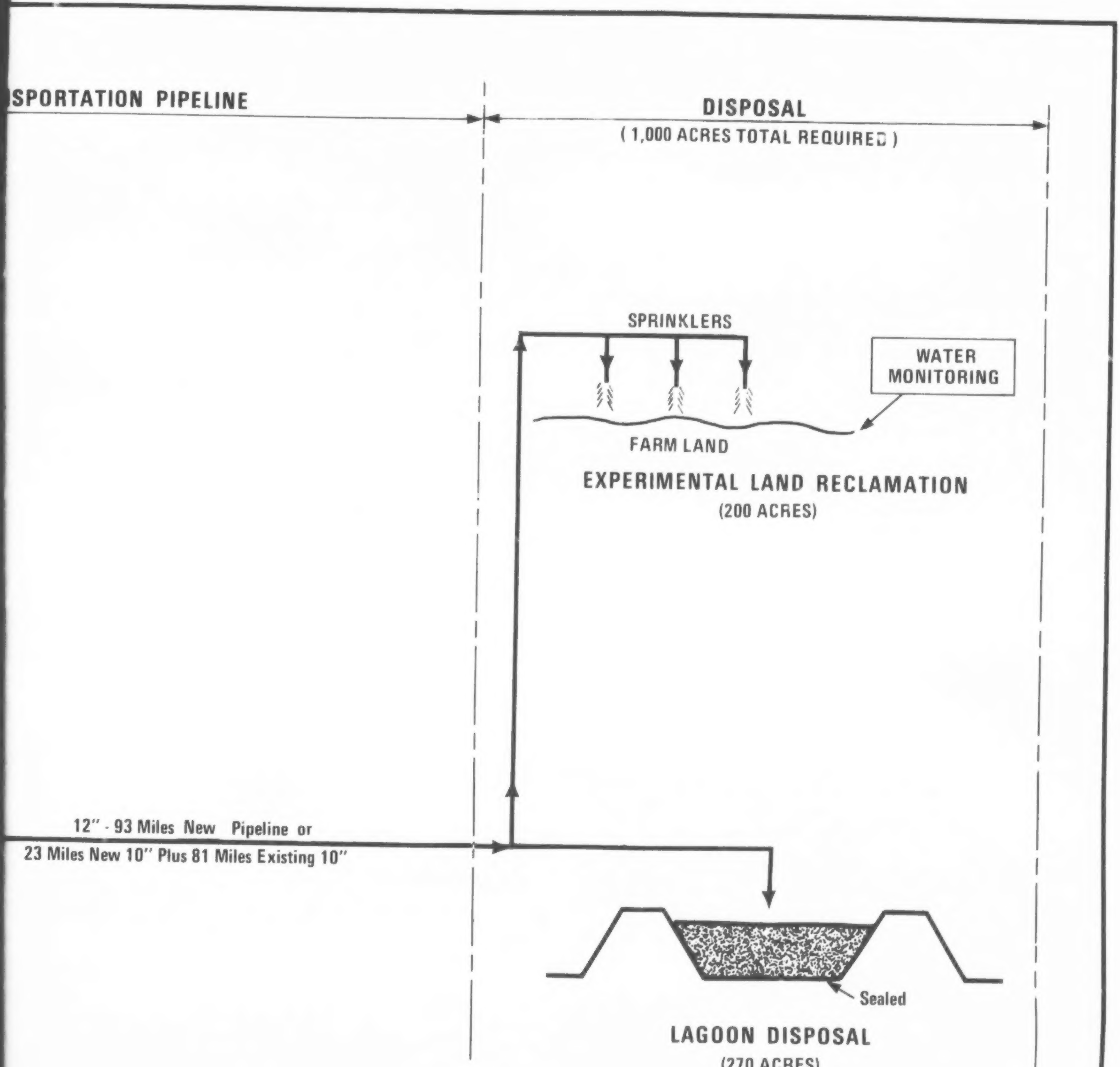
PRODUCTION	
Year	Tons/Day
72	108
73	110

A

P.C.A. Waste Management Study

Figure 9

ISTRATION PROJECT SYSTEM – DIGESTED SLUDGE


SPORTATION PIPELINE
DISPOSAL
(1,000 ACRES TOTAL REQUIRED)
SPRINKLERS
WATER MONITORING
FARM LAND
EXPERIMENTAL LAND RECLAMATION
(200 ACRES)
12" - 93 Miles New Pipeline or
23 Miles New 10" Plus 81 Miles Existing 10"
Sealed
LAGOON DISPOSAL
(270 ACRES)

B

BASIS OF ECONOMIC

BASIS

PIPELINE

DESIGN BASIS

- 12-inch Diameter Pipe
- Pipe Velocity - > 3.0 ft./sec.
- Route
  - 35 miles suburban
  - 58 miles rural

CAPITAL INVESTMENT - including

- Pipe & Fittings
- Installation Cost
- Pump Stations
- Right of Way
- Instrumentation and Control
- Indirects

ANNUAL CHARGES

- Capital Repayment over 25 years
- Interest Rate at 6 percent
- Annual Capital Repayment 7.82%
- Direct Operating Costs, including
  - Power at 1¢ KWH
  - Labor at $15,000/man
  - Supplies
  - Maintenance

(Tons of Solids/Day)	P
	Capital
130	10.46
200	6.50
300	4.69
400	3.96

F.W.P.C.A. Waste Management Study

Figure 10

NOMICS OF TRANSPORTATION OF DIGESTED SLUDGE

NORTHEAST OHIO REGION

BASIS: 3.5 Weight % Solids, 93 Miles to Disposal

RAILROAD

DESIGN BASIS

- Unit Trains
- Two Trains Required
- Car Capacity - 100 tons
- Loading and Unloading - 16 hours
- Round Trip - 2 days

CAPITAL INVESTMENT

- Tank Cars @ $25,000 per car
- Loading and Unloading Facilities — not included
- Capitalization of Rail Network — included in annual operating charge

ANNUAL CHARGES

- Capital Repayment over 25 years
- Interest Rate at 6 percent
- Annual Capital Repayment 7.82%
- Direct Operating Costs — Railroad Supplies, Power, Capitalization and Return Trip Charged at 1.0 cent/ton mile Maintenance at 1.5¢/car mile

TRUCK

DESIGN BASIS

- 24-hour per day Operation
- Truck Capacity - 6,000 gallons
- Truck Availability at 80%
- Average Speed
  - Downtown 15 mph
  - Country 30 mph
- Loading and Unloading - 30 mins.

CAPITAL INVESTMENT

- Truck and Trailer @ $35,000
- Loading and Unloading Facilities not included

ANNUAL CHARGES

- Capital Repayment over 10 years
- Interest Rate at 6 percent
- Annual Capital Repayment 13.59%
- Operating Costs, Including Fuel, Labor and Maintenance at $20 per hour

UNIT TRANSPORTATION COST ($/Ton of Solids)

PIPELINE			RAILROAD			TRUCK		
Capital	Operating	Total	Capital	Operating	Total	Capital	Operating	Total
10.46	4.70	15.16	3.82	34.80	38.62	5.25	155.00	160.25
6.50	3.20	9.70	3.82	34.80	38.62	5.25	155.00	160.25
4.69	3.30	7.99	3.82	34.80	38.62	5.25	155.00	160.25
3.96	3.45	7.41	3.82	34.80	38.62	5.25	155.00	160.25

B

railroad is shown in Figure 11. This holds true in spite of the fact that the pipeline system is oversized for the demonstration project tonnages so as to be compatible with future expansions. Also, it should be noted that no charges for loading and unloading have been included for the rail and truck cases, but they are included for the pipeline case.

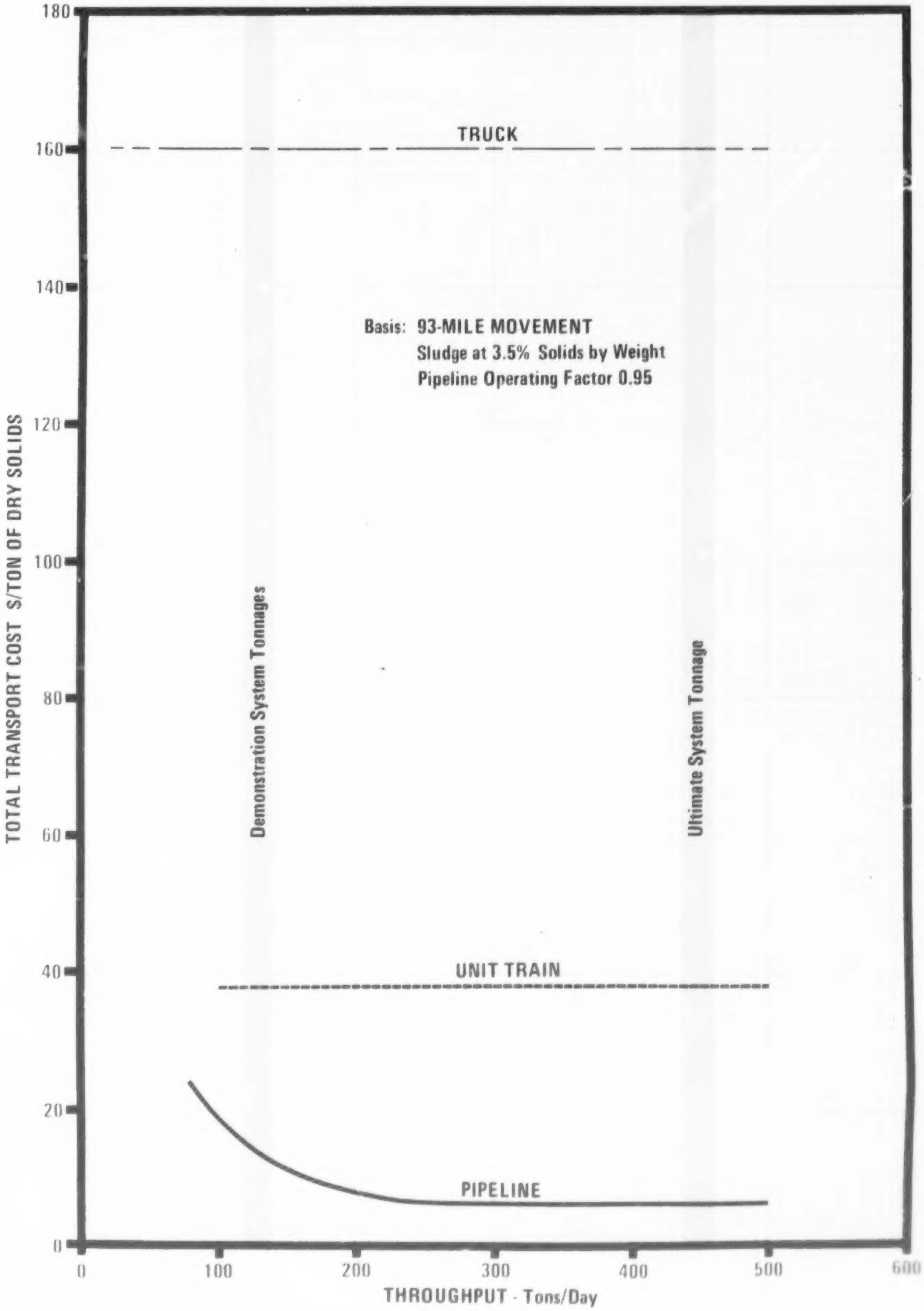
The main reason that pipeline is more economic than truck or rail is that a larger portion of its costs are in the form of capital related costs. With an interest rate of 6% and a capital payback of 25 years for financing the system, annual capital charges are relatively light. The only capital expenditure for the railroad is the purchase of tank cars for the unit trains. Since tracks already exist from the disposal site to the collection point, capitalization of the rail net is included as an operating charge levied by the railroad company. The effect of capital charges can be seen by examination of the table of transportation costs in Figure 10. For a distance of 93 miles and throughputs up to 400 tons per day, the pipeline capital charges are consistently higher than the direct operating costs. The pipeline operating costs decrease gradually with increased tonnages transported while with truck and rail little change in operating cost takes place.

A 12-inch pipeline will be used to transport digested sludge 93 miles from the collection point at Southerly to the disposal site. A single pump station, located at Southerly, is sufficient for the requirements of the demonstration period. A positive displacement pump, driven by a 1250 horsepower electric motor, will be used.

Since the pipeline is sized to satisfy the disposal requirements of the whole Northeast Ohio region, the sludge will be batched through the pipeline during the demonstration project at a velocity of 3 to 3-1/2 ft/sec.

Figure 11

F.W.P.C.A. Waste Management Study
COMPARATIVE ECONOMICS
OF DIGESTED SLUDGE TRANSPORTATION SYSTEM



(The profile and hydraulic gradient for both the demonstration and the ultimate system is shown on Figure 16, which is presented in a later section).

Land Disposal Terminal

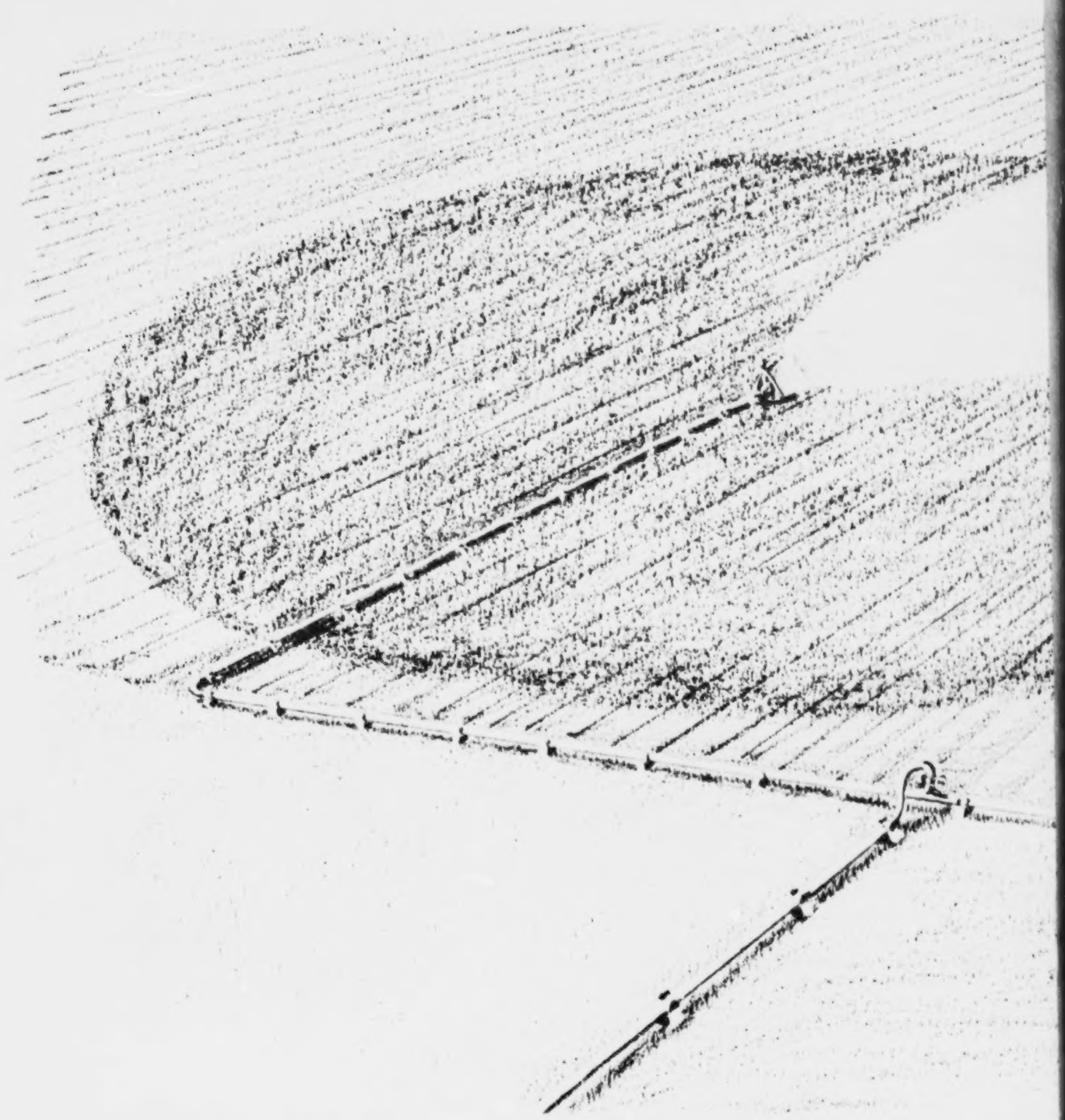
The system proposed for the land disposal of digested sludge is shown in Figure 9. The disposal scheme consists of:

a) Lagoons (basic disposal system)
b) Land application facilities (experimental)
c) Support facilities, including ground and surface water monitoring, laboratory test facilities.

Initially, at the terminal end of the system in Harrison County, sludge disposal would be by means of the time-proven lagooning method where sludge is simply deposited as a slurry in lined lagoons and later (about 18 months) the dried sludge is removed by front-end loader and truck and spread on land as a soil conditioner. Monies are included in the estimate for this lagooning system which is adequate for the first three years of operation. It is planned that during the two years of demonstration system operation, a small scale experimental program would be carried out to investigate the practicality of spreading the as-received sludge by means of a sprinkler distribution system. (See Figure 12). If this method is successful, full-scale irrigation and sprinkling equipment would be installed in 1974 immediately after the demonstration period and from that point on the lagoons would be used simply for surge and backup disposal. Should the sprinkling and irrigation system prove not to be practical, then the lagooning system could be expanded. This approach is taken in order to be conservative since lagooning is a proven disposal method and the benefits of lagoon dried sludge as a soil conditioner have been established. In any

F.W.P.C.A.

LAND DISPOSAL – LA



A

Waste Management Study

AND RECLAMATION CONCEPT

Figure 12

B

event, during the two-year demonstration both systems may be observed and evaluated prior to selection of the final system to be used.

Furthermore, it should be noted that the Chicago Land Disposal Study(3) which is a large scale demonstration of land disposal, will be completed in 1972. This is excellent timing since it gives ample time to analyze the results of this work and evaluate its applicability, if any, to the Ohio disposal area prior to 1974 when a decision should be made on selecting a long-term disposal method.

Approximately 270 net acres will be required for lagooning: 54 lagoons at 5 acres each. The lagoons would be about 6 feet deep and 470 feet square. They would be lined with an impervious clay bed. After the drying period of about 18 months during which the material may dry to approximately 25 percent solids, it would be mechanically loaded and trucked away. Approximately 5 miles of 10-inch distribution piping is included to distribute the sludge to the various lagoons. Total disposal area required for the demonstration period would be about 1000 acres.

It should be noted that the lagoons are sized to dry the sludge to 25 percent solids under average climatic conditions. If the material is less concentrated than planned, then the possibility of distributing this thinner material either by truck or pipeline would be investigated. In the ultimate system, for example, the lagoons could be used solely for the purpose of concentrating, if this proved to be a desirable method of operation.

DEMONSTRATION PROJECT COSTS

Total costs and a breakdown of capital costs for the demonstration project are set forth in Table 4. As shown, the total estimated cost for the two-year demonstration is $10.8 million, composed of $9,100,000 in capital costs and $1,700,000 in operating costs. These are total system costs to transport and dispose of the digested sludge from the Southerly sewage treatment plant for the two-year demonstration period.

Capital costs include direct material and installation costs for pipe, valves, pumping facilities, land application terminal and laboratory test facilities as well as right-of-way. In addition to the direct costs, the system capital cost estimate includes the indirect costs of engineering, procurement, management of construction, a contingency allowance and interest during construction. Escalation is included to 1971 as a separate item.

Direct operating costs for the two-year demonstration are shown in Table 5. These costs include electrical power, operating labor, supplies, contract maintenance, land rental and land preparation. Costs are for the complete system including both transportation and disposal. System management costs have been included for organizing and managing the demonstration project. This includes technical evaluation and interpretation of the data generated during the demonstration. In addition, costs are included for a development program directed primarily at land application.

TABLE 4

F.W.P.C.A. WASTE MANAGEMENT STUDY

TOTAL COSTS FOR TWO YEAR DEMONSTRATION PROJECT

(New 12" Pipeline)

		COST
CAPITAL COSTS:		
Pipeline - 93 Miles of 12"		$ 5,215,000
Pump Station - 1300 Installed HP (1250 HP P.D. Pump + 50 HP Booster)		570,000
Right-of-Way		1,085,000
Lagoon System and Irrigation Plots		
Lagoon System		
-270 acres of lagoons and 5 miles of 10" feeder pipe	855,000	
-loading and spreading equipment	230,000	
	$1,085,000	
Irrigation Plots		
-Land preparation (200 acres) including drain tiles and stream protection	110,000	
-Distribution and sprinkler system	320,000	
-Farm equipment and maintenance garage	75,000	
	$505,000	
Environmental Control		
-Water monitoring equipment	50,000	
-Laboratory facilities	130,000	
	$180,000	
Total Lagoon and Irrigation (1969 Dollars)		1,770,000
Escalation		
To 1971		460,000
TOTAL CAPITAL COSTS		$ 9,100,000
TOTAL DIRECT OPERATING COSTS*		$ 1,700,000
TOTAL DEMONSTRATION COSTS		$10,800,000

*Two Year Total --See Table 5

TABLE 5
F.W.P.C.A. WASTE MANAGEMENT STUDY

DIRECT OPERATING COSTS
FOR
TWO YEAR DEMONSTRATION PROJECT

ITEM		Total Two Year Cost
Transportation		
Power, labor and supplies		$ 440,000
Lagoon System and Irrigation Plots		
Lagoon maintenance	$ 65,000	
Trucking operation	120,000	
Farm operation	180,000	
Water monitoring	25,000	
Land Rental	20,000	410,000
Development Program		
Transportation and land application	$ 140,000	
Agricultural support	100,000	
		240,000
System Management		500,000
Escalation - To 1971		100,000
TOTAL OPERATING COSTS		$1,690,000
	Say	$1,700,000

DEMONSTRATION SYSTEM OPERATION AND DEVELOPMENT PROGRAM

The operating objectives of the two-year demonstration program are as follows:

1. Remove all digested sludge and supernatant produced by the two major treatment plants in Cleveland.
2. To provide reliable and safe transport of the waste material to the disposal area.
3. To effect disposal of the waste material without contaminating the disposal area environment.
4. Develop methods to increase the efficiency of the pipeline-land waste disposal system for digested sludge and other materials.

Pipeline Operation

The 12-inch pipeline from Southerly to Harrison Country will be operated on a five-day-per-week basis during the demonstration program. Pipeline flow, sludge density and pump discharge pressure will be monitored continuously during operation.

To prevent the formation of any excessive deposits on the inside pipe wall, the line will be "pigged" as required. The pipeline route will be patrolled at regular intervals as a form of preventive maintenance.

Disposal Terminal Operation

During the demonstration period, sludge will be disposed of by lagooning. A series of 54 lagoons covering 270 acres will handle the requirements for the two-year program.

In the first year of operation, a portion of the lagoons will be filled with sludge. As the program progresses, it will be possible to excavate and reuse some of these lagoons. The sludge cake will be disposed of by spreading on land.

During the second year of operation, the lagooning will continue, but a portion of the sludge will be used in an experimental program for spreading liquid sludge on land (to be discussed later).

Development Program

During the operation of the demonstration system, a development program will be conducted. The purpose of this program will be to obtain information on land disposal of digested sludge and other waste materials, which will allow optimization of the pipeline-land disposal system prior to proceeding with the full scale regional system.

The program will investigate aspects of land application for optimizing the system economics while meeting all environimental standards.

Land Renovation

Two hundred acres of land will be set aside for basic test work on the land application of liquid sludge. The sludge will be applied to the land by means of a sprinkler distribution system. The exact nature of the tests will be formulated on the basis of data produced from smaller scale testing performed by the University of Illinois for the Chicago Sanitary District and will be complementary to that work. The principal objectives will be:

1. To investigate, under field conditions, the method, frequency, rate, and time for safely applying digested sludge on land.
2. To investigate the effect on surface waters and groundwater when varying amounts of digested sludge are applied to different types of soil.

3. To investigate factors relevant to the pollution of soils with heavy metals, high soluble salt concentrations, grease and organic compounds.
4. To evaluate the effects of including other wastes, such as fly ash or water treatment plant sludge, on the land disposal system.
5. To correlate these large scale data to laboratory or pilot tests, so that results on other types of soils can be predicted in the future without the necessity for full scale tests.

The test plot will be selected to encompass natural drainage basins on the side of a hill. The test plot will start at the ridge line at the top of the hill and will use the valley at the bottom to form a natural water collection system. Only fields which form these natural basins will be used.

A series of fields about ten acres in size will be set up to take annual loadings of 1/2, 1, 2, 4, 8, 16, 24, 36 and 48 inches of digested sludge per year. Each test field will be set up so as to allow intensive monitoring of the groundwater. An adequate number of test fields (e. g. , four sets) will be used so that the influence of different types of soil, time of year for application and field grading can be evaluated.

A control laboratory will be established to handle the standard and special tests on water samples obtained from monitoring surface streams and groundwater wells. The laboratory will also carry out a program to develop,by correlation with the large scale tests, test methods to evaluate different soil capacities for the various groundwater contaminates.

Work will also be carried out to determine the effect of adding other waste materials or chemicals to the digested sludge to improve crop production or soil conditioning. For example, if the soil is acid, lime may be advantageously added to the sludge to increase the soil pH. This pH adjustment may also be accomplished by incorporating fly ash or water treatment plant sludge into the disposal system. Also, tests can be made on the effect of adding potash to achieve a more balanced fertilization with the waste materials.

Water Pollution

An evaluation of groundwater contaminate behavior in the test plots will be made and compared to laboratory test results using the same soil loading program. From these data and data from other current and completed studies, it should be possible to build up a history of experimental data to facilitate prediction of the results of adding waste materials to various soils.

Pipeline Development

The pipeline experimental program will consist of the following tests, observations and determinations:

1. Pumping energy requirements will be determined as a function of sludge solids content and sludge velocities.
2. Shear stress vs. apparent rate of shear curves will be obtained on the sludges which are used in the pumping energy requirement experiments. This will be accomplished by using a laboratory-type rotational viscometer.

3. Data obtained in the pumping energy requirement experiments will be examined for evidence of thixotropic breakdown with downstream distance in the pipeline. Correlation of viscometer data and pipeline data will be carried out.
4. Long-term pumping experiments will be carried out over the two-year period. A record of operating and maintenance data and costs will be kept. Particular care will be exercised in observing pump performance, corrosion, erosion, buildup of solids, nature of solids which build up, and cleaning and water flushing schedules. In addition, shutdown-startup tests will be carried out.
5. The amount of gas production (if any) from the sludge during pipeline transportation will be evaluated.
6. A portion of the pipeline development will be the demonstration of long distance pipelining of other materials such as fly ash, water treatment plant sludge, and dredgings. Experiments similar to those described above for digested sewage sludge would also be performed on these materials.

ENVIRONMENTAL CONTROL

The basic purpose of the land disposal system is the economic disposal of waste material by methods which will not pollute the environment. The general methods to be used to accomplish this goal in the present system, both during normal system operation and a system malfunction, is discussed in the following sections.

Collection System

At the inlet to the pipeline transport system, several days of storage will be provided by the treatment plant's existing sludge disposal facilities. This should ensure adequate time for pipeline or pump station repairs. During the demonstration program, the existing filters and incinerators will be maintained in such a condition that they can be placed back into operation at short notice.

Pipeline Transport System

The pipeline will be buried with motor operated valves located typically at intervals of five miles, depending on population density in the area. Provision will be made to indicate the unlikely event of a pipeline break by pressure sensing controls. The operator will be able, by remote control from the main control room to close the block valves on each side of the line break in order to isolate the damaged pipeline area and minimize liquid losses. If a leak occurs, temporary dams will be constructed to prevent the sludge from contaminating the local streams. The sludge will be recovered from these dams and trucked to the disposal site.

Disposal System

In the land application areas, application rates and other factors will be controlled to prevent water pollution, odor, and insect problems. Both surface and groundwater will be monitored for excess nitrates. If a situation develops where surface water may contaminate the surrounding streams and rivers, the run-off streams will be contained by secondary dams downstream and the water pumped back to the lagoons for redistribution on the land.

In the downstream flow path of the groundwater from the disposal area, wells will be used to monitor the groundwater. If any pollution of the groundwater is detected, sludge application will be reduced or discontinued. The large scale land application tests to be conducted during the demonstration program, together with a coordinated laboratory program, will provide the information necessary to ensure that sludge overapplication will not take place. No odor or insect problems have been reported with the application of well digested sludge on land. However, in areas where no useful vegetation exists, the sludge will be disced into the soil after the last application for the year to further decrease any chance of an odor or insect problem.

The disposal lagoons will be lined with an impervious material. Clay is available. The lining will be examined each time a lagoon is excavated, and will be repaired or replaced when necessary to prevent uncontrolled seepage into the groundwater.

EXPANSION TO MEET FUTURE REGIONAL REQUIREMENTS

With the successful completion of the demonstration program as described in the previous sections, information and experience will be available so the demonstration facilities can be expanded into a full regional disposal system.

In the regional system, dredgings and digested sludge, the materials of major concern, will be handled by separate pipeline systems. Although, as shown in Volume III of this study, it is technically feasible to handle both materials in a single line, the nature and ultimate uses of each material makes it more practical to handle them separately. An alternative for dredgings transportation,using the spare capacity available in the sludge pipeline in the early years of operation,is discussed later.

In this section, the action necessary to meet future requirements of the Northeast Ohio region will be discussed and the costs associated with these expansions will be presented.

Digested Sludge Disposal System

The regional disposal system for digested sludge will be expanded to include the Westerly, Rocky River and Southerly metro system and Canton sewage treatment plants, as shown in Figure 13. A study of the relative economics of using trucks or pipeline for the collection system (by cities) has shown that pipeline is the most economic mode of transport. Figure 14 shows the results of this comparison. Waste volume projections up to the year 2000 for this expanded system are shown in Table 2, and the bases of

Figure 13

F. W. P. C. A. WASTE MANAGEMENT STUDY

NORTHEAST OHIO REGIONAL SYSTEM - YEAR 2000

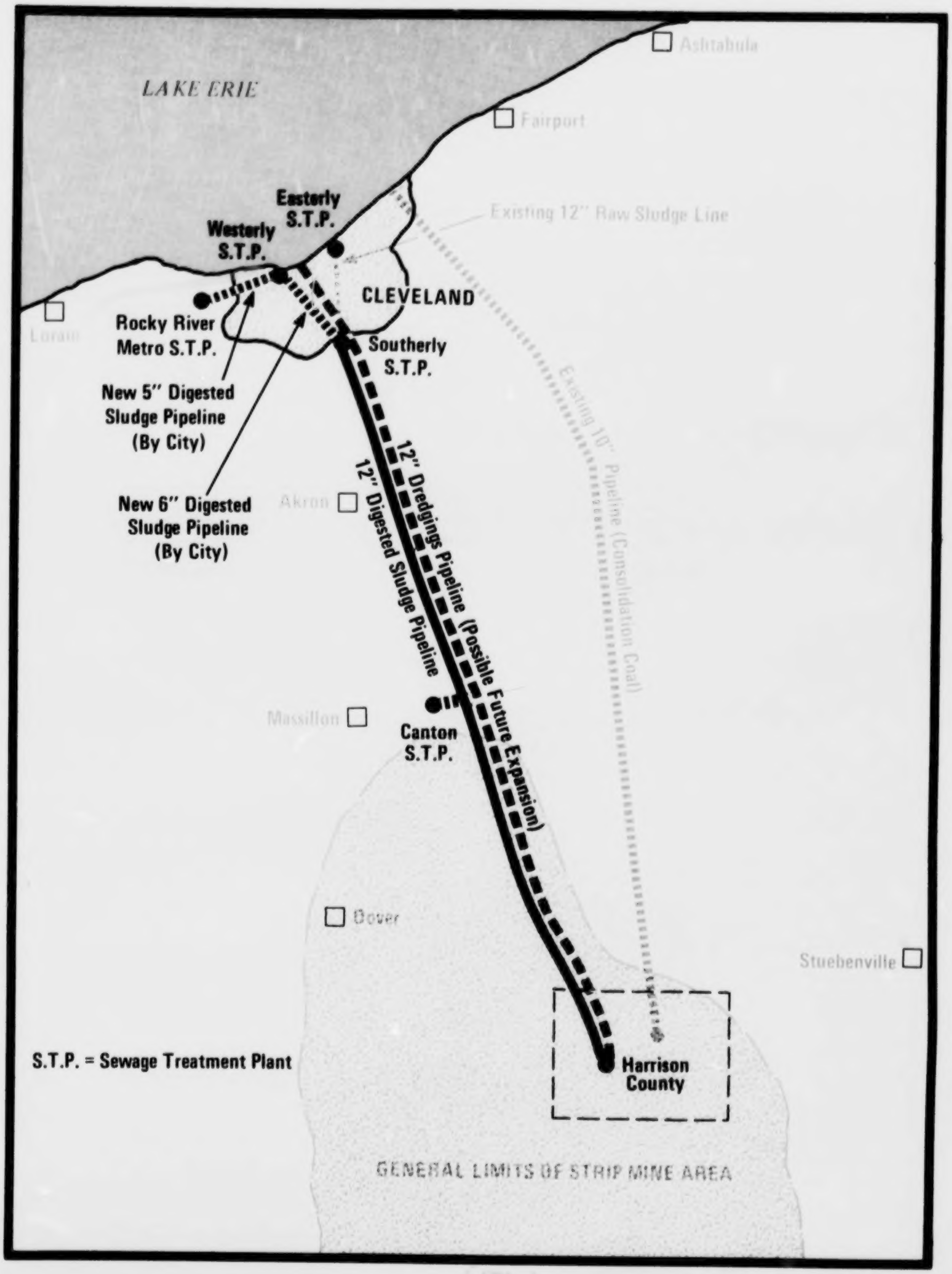
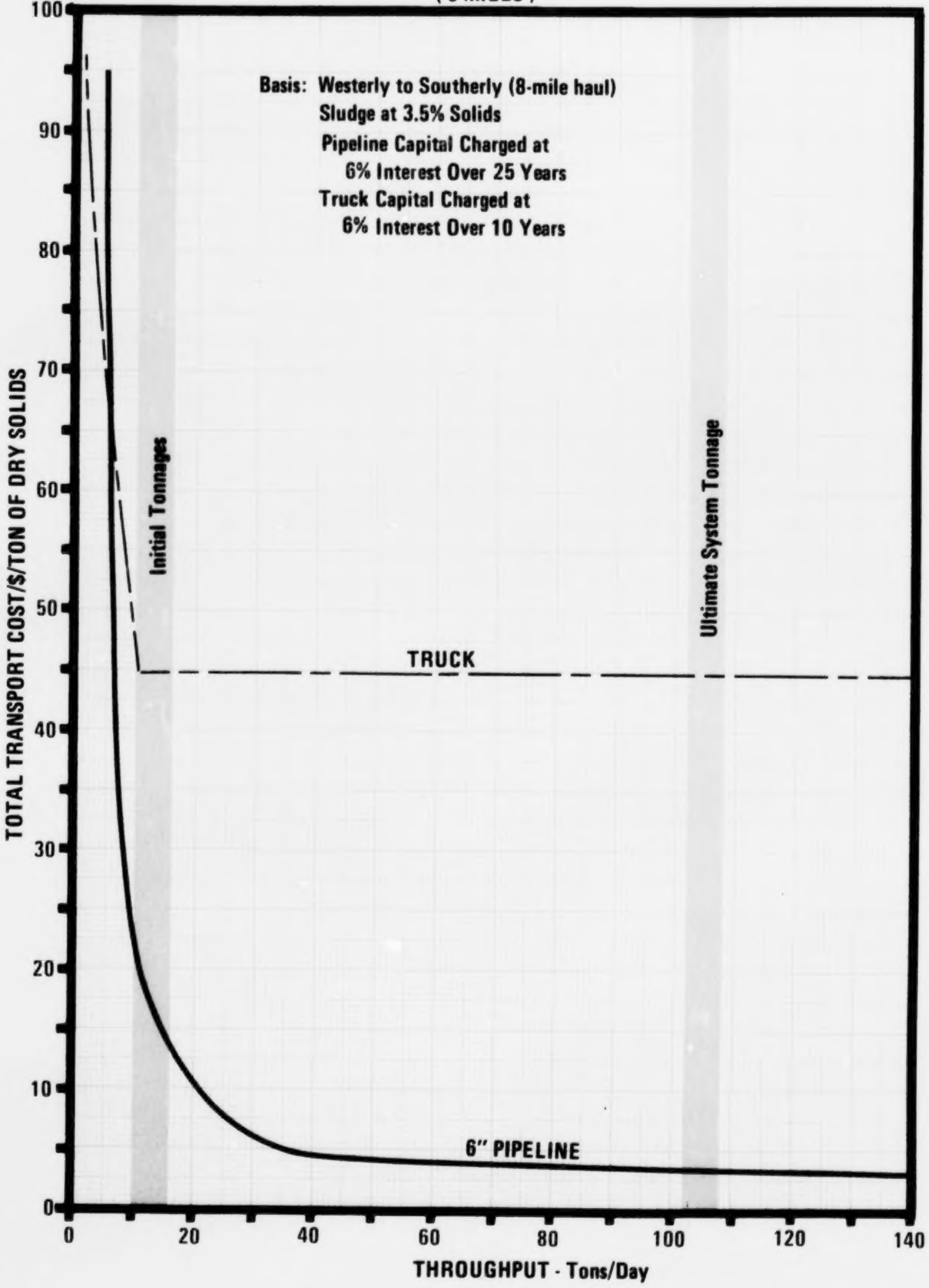

LAKE ERIE
Ashtabula
Fairport
Existing 12" Raw Sludge Line
Easterly S.T.P.
Westerly S.T.P.
CLEVELAND
Lorain
Rocky River Metro S.T.P.
Southerly S.T.P.
New 5" Digested Sludge Pipeline (By City)
New 6" Digested Sludge Pipeline (By City)
Existing 10" Pipeline (Consolidation Coal)
12" Dredgings Pipeline (Possible Future Expansion)
12" Digested Sludge Pipeline
Akron
Massillon
Canton S.T.P.
Dover
Stuebenville
Harrison County
S.T.P. = Sewage Treatment Plant
GENERAL LIMITS OF STRIP MINE AREA

Figure 14

F.W.P.C.A. Waste Management Study
COMPARATIVE ECONOMICS
OF DIGESTED SLUDGE COLLECTION SYSTEM
(8 MILES)



the development of these projections are presented and discussed in Appendix B.

Figure 15 is a flowsheet of the regional sludge disposal system including all the facilities expansions up to the year 2000. It should be noted that at this time the Akron sewage treatment plant has not been included in the regional system. The reason for this is that Akron is currently installing a wet oxidation unit to dispose of secondary sludge, and it is unlikely that it will wish to participate in this system until a major expansion is required or major operational difficulties occur. If, however, it is decided that Akron will become part of the regional system, the system unit costs would be greatly reduced, since, for a minor increase in capital expenditure, the system capacity would be increased by some 30 percent. However, the capacity must be built into the system initially.

The individual additions to the collection, transportation and land distribution systems are shown in Table 6, indicating the year of installation and capital cost requirements. As shown, \$5.7 million in additions are required during the operating period, making an ultimate system capital cost of \$ 14.8 million (\$9.1 plus \$5.7 million).

As shown in Table 7, the average daily tonnage will increase from 128 tons/day to 409 tons/day over the period 1974 to the year 2000. This is a projected increase in sludge quantities of 219%, which is largely due to the assumed implementation of the Metro system concept plus the addition of waste chemical sludge from chemical precipitation of phosphorus.

In comparison, the operating costs over this period will nearly double.

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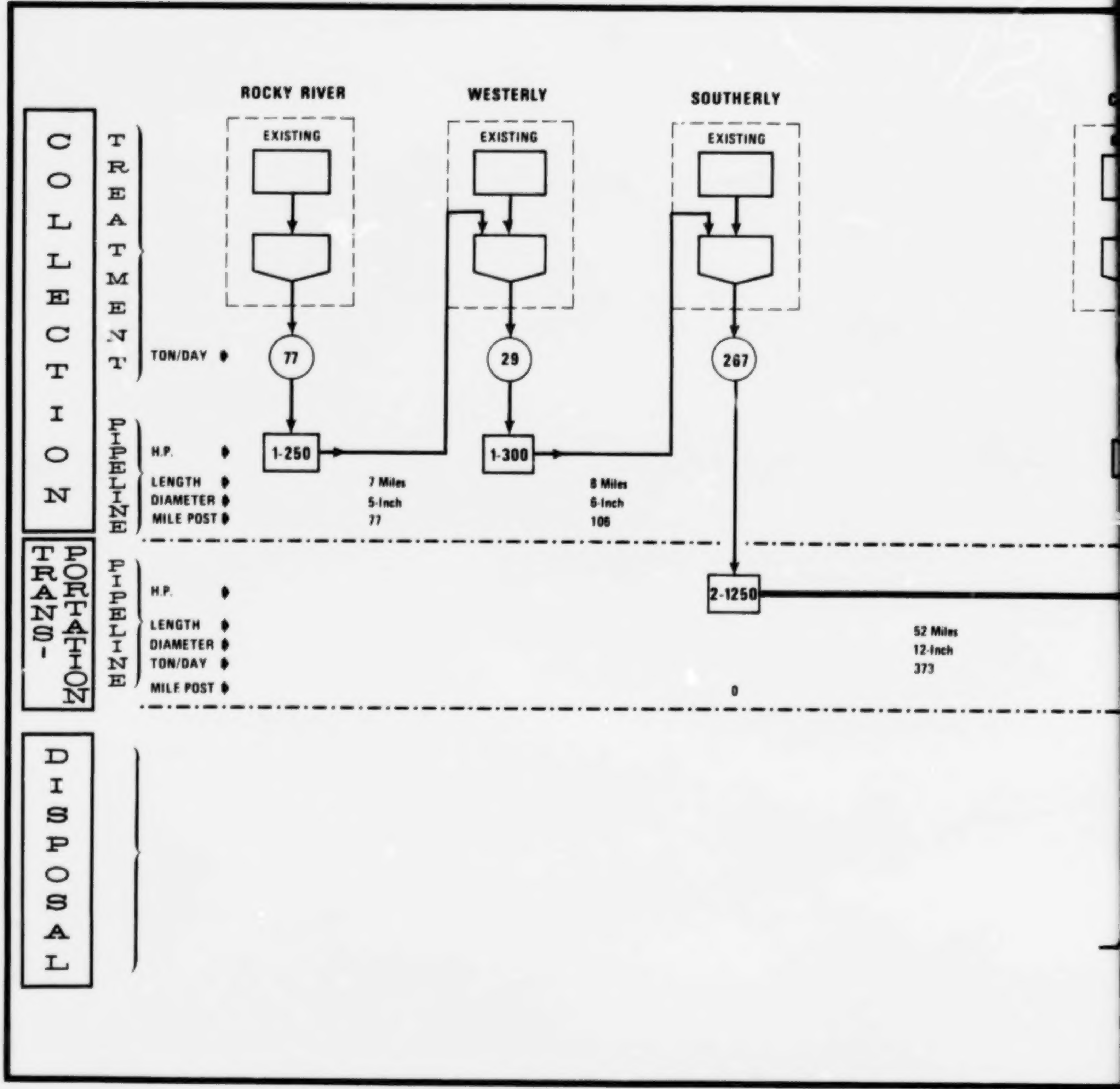
FACILITIES SUMMARY OF LAND DI

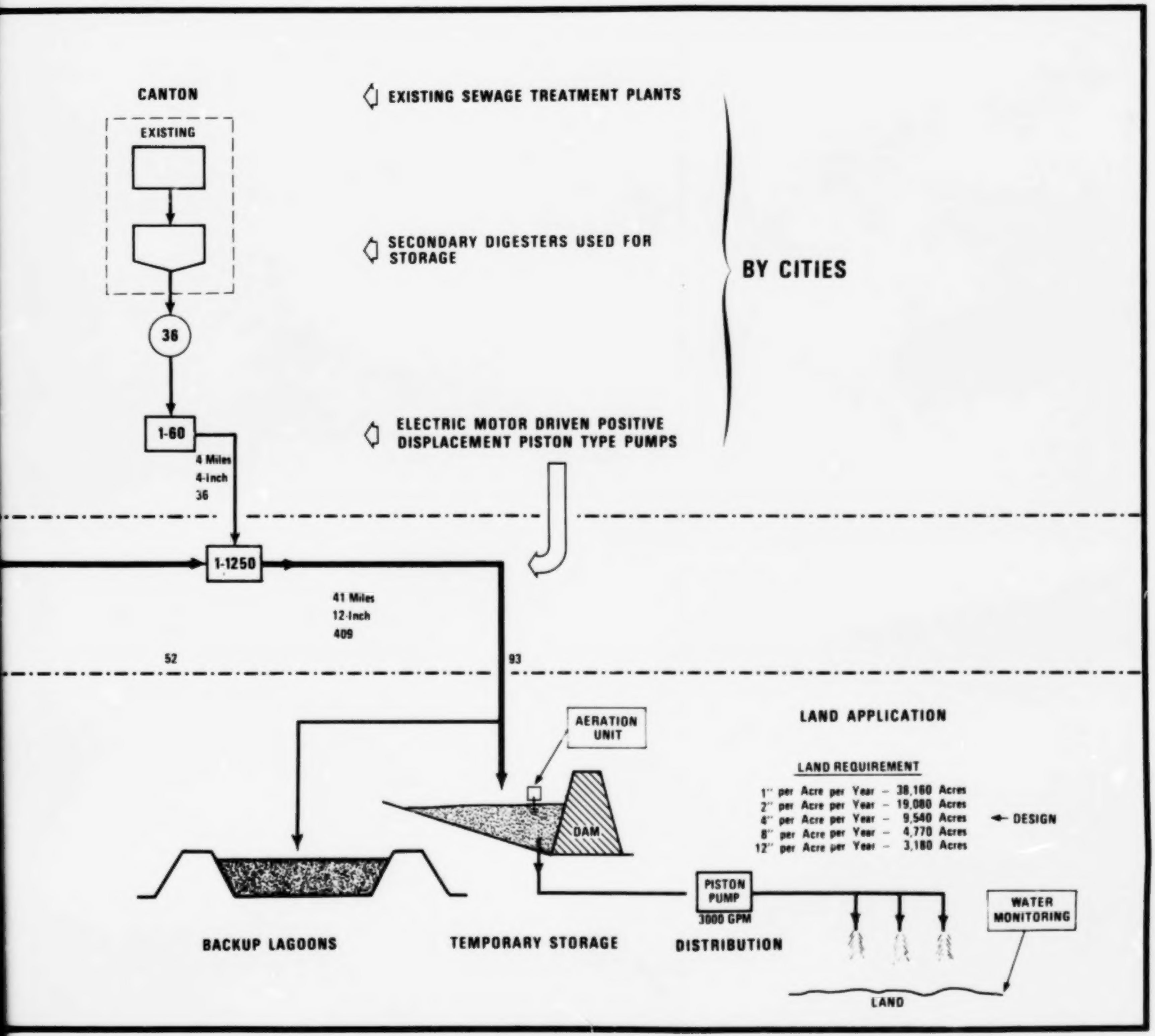

COLLECTION
TRANS-PORTATION
DISPOSAL
TREATMENT
PIPELINE
PIPELINE
ROCKY RIVER
WESTERLY
SOUTHERLY
EXISTING
EXISTING
EXISTING
TON/DAY
77
29
267
H.P.
1-250
1-300
LENGTH
DIAMETER
MILE POST
7 Miles
5-Inch
77
8 Miles
6-Inch
106
H.P.
2-1250
LENGTH
DIAMETER
TON/DAY
MILE POST
52 Miles
12-Inch
373
0

55

A

F.W.P.C.A. Waste Management Study

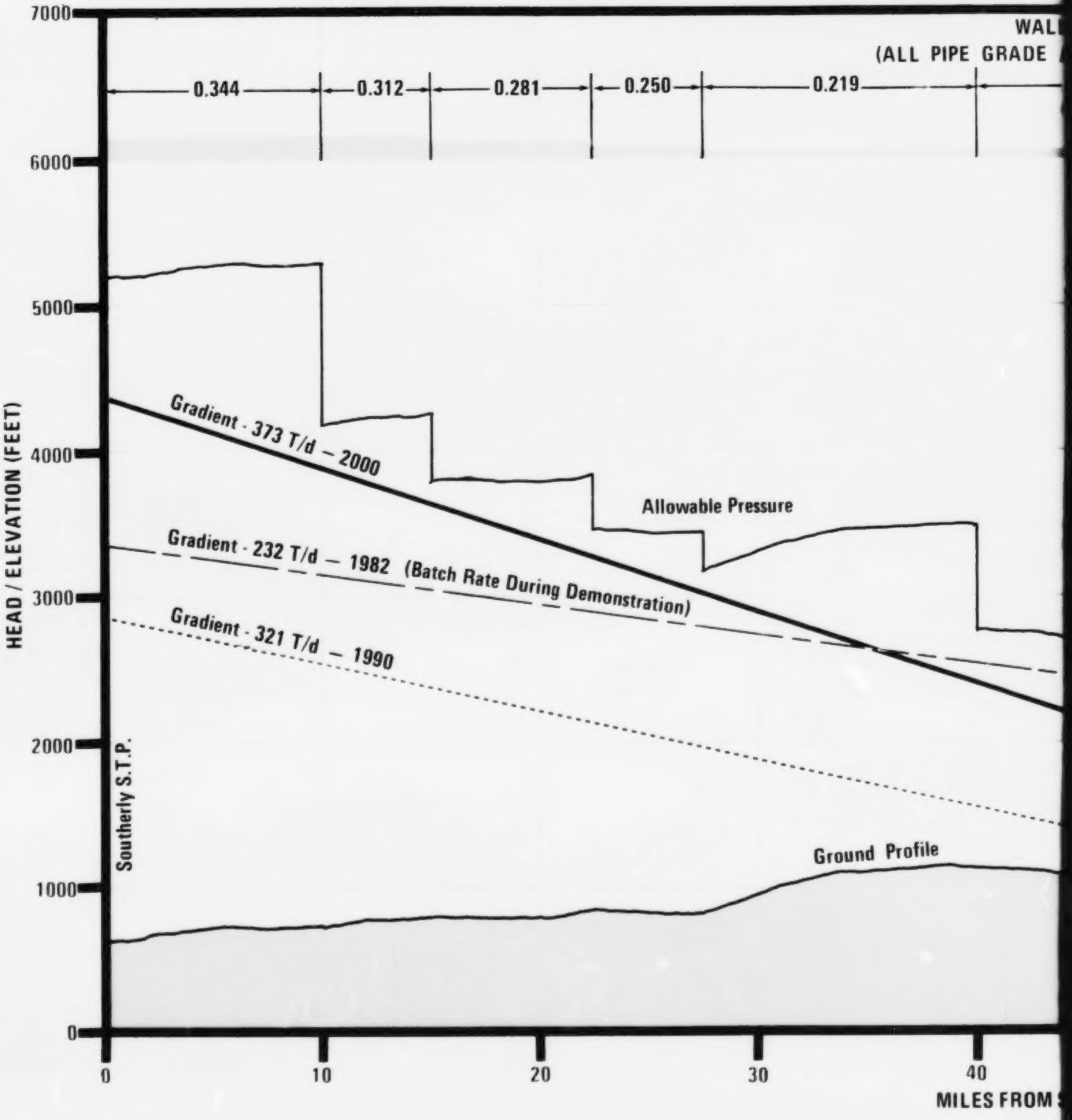
OF LAND DISPOSAL SYSTEM – DIGESTED SLUDGE


CANTON
EXISTING
36
1-60
4 Miles
4-Inch
36
1-1250
41 Miles
12-Inch
409
52
93
EXISTING SEWAGE TREATMENT PLANTS
SECONDARY DIGESTERS USED FOR STORAGE
ELECTRIC MOTOR DRIVEN POSITIVE DISPLACEMENT PISTON TYPE PUMPS
BY CITIES
AERATION UNIT
DAM
LAND APPLICATION
LAND REQUIREMENT
1" per Acre per Year – 38,160 Acres
2" per Acre per Year – 19,080 Acres
4" per Acre per Year – 9,540 Acres
8" per Acre per Year – 4,770 Acres
12" per Acre per Year – 3,180 Acres
← DESIGN
PISTON PUMP
3000 GPM
WATER MONITORING
LAND
BACKUP LAGOONS
TEMPORARY STORAGE
DISTRIBUTION

B

F.W.P.C.A. Wa

NORTHEAST OHI
GROUND PROFILE &
12" DIGESTED SLUDG



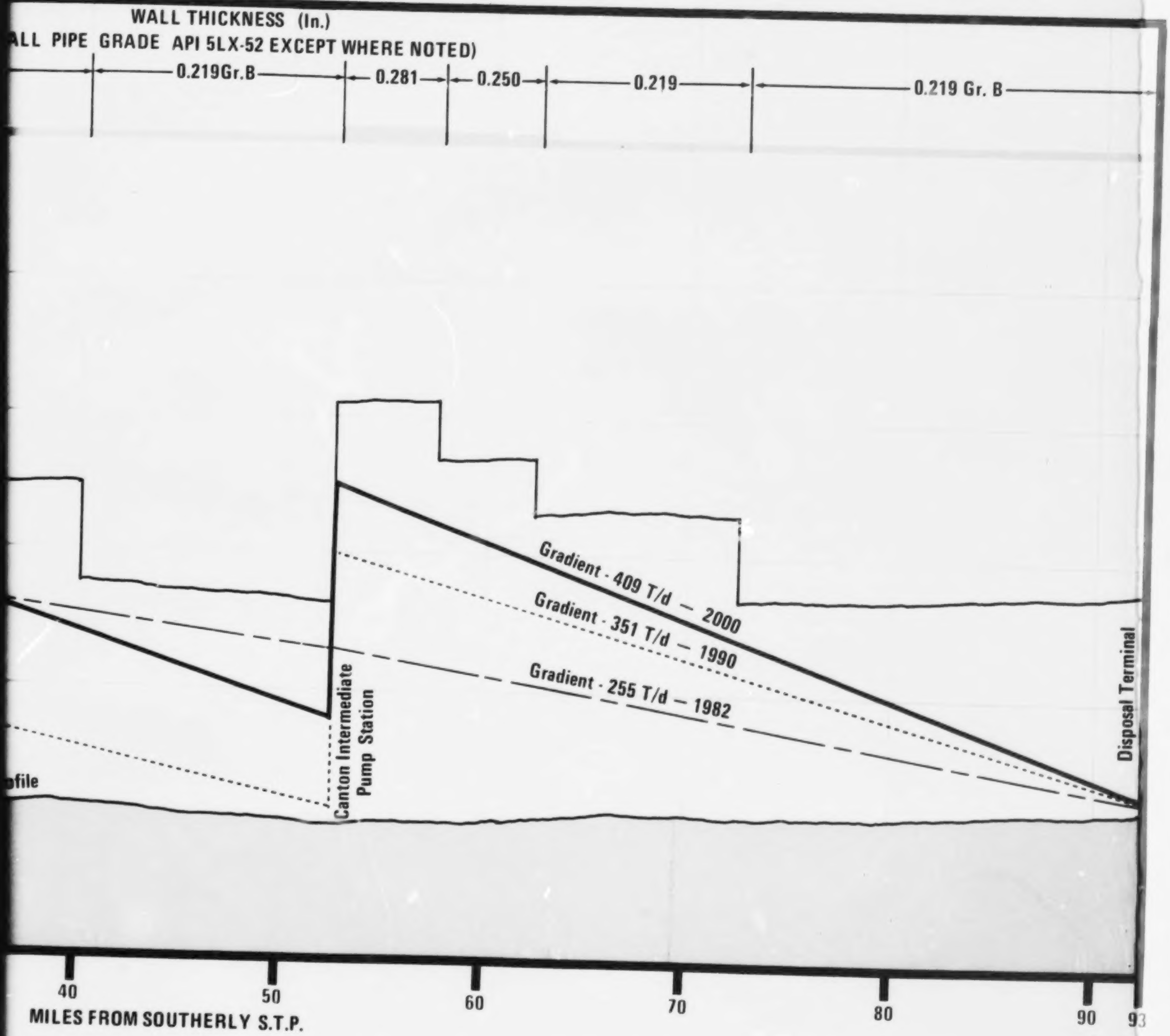
(56)

A

F.W.P.C.A. Waste Management Study

Figure 16

EAST OHIO REGIONAL SYSTEM
PROFILE & HYDRAULIC GRADIENT
TED SLUDGE PIPELINE 3.5% SOLIDS



B

Since most of the capital investment is made at the start of the period, the resulting unit costs of disposal are initially high but rapidly decrease with increased tonnages. The costs at five year increments are shown in Table 8. The average cost for the twenty-nine year period is $23.18 per ton expressed in 1971 dollars. Average cost over the same period of the collection system provided by the cities is $1. 90 per ton.

As shown in Table 6, land is included at $100 per acre. This, of course, is subject to negotiation and is included here for illustrative purposes only. Approximately 10,000 total acres are required. Using a cost $100 per acre higher (i. e. $200 per acre) would increase the ultimate investment by $1,000,000, which is approximately equivalent to 75¢ per ton in the average year.

Potential Savings

As indicated in Appendix D, direct costs of sludge filtration and incineration at Cleveland's Southerly plant have averaged around $25/ton for the period since 1960 (excludes capital charges). However, it should be noted that implementation of chemical precipitation would result in increasing the inorganic content of the sludge. Fuel requirements for incineration would rise and disposal costs could increase substantially from this value. However, operating costs of $25/ton have been used in projecting future sludge disposal costs for all plants to be served by the regional system. The future cost of sludge disposal by present methods assumes that plant improvements are made at Southerly, resulting in improved solids recovery and therefore higher tonnages. (See Appendix D).

TABLE 6
F. W. P. C. A. WASTE MANAGEMENT STUDY
NORTHEAST OHIO REGIONAL SYSTEM
ADDITIONS AND COSTS
(New 12" Pipeline)

Year Added	Item	Capital Cost
COLLECTION (By Cities)		
1973	Westerly Feeder - 150 HP plus 8 mi. 6" pipeline	$ 515,000
1974	Canton Feeder - 85 HP plus 4 miles of 4" pipeline	350,000
1980	Rocky River Feeder - 350 HP plus 7 mi. of 5" pipeline	775,000
1981	Westerly pump station addition - 300 HP	340,000
	Subtotal	$1,980,000
TRANSPORTATION		
1981	Booster pump station - 1250 HP	570,000
1989	Southerly pump station addition - 1300HP	415,000
	Subtotal	$ 985,000
LAND DISPOSAL		
1974	Land purchase allowance 6600 acres @ $100/acre	$ 660,000
	Temporary storage allowance 450 acre feet (6 weeks ±)	860,000
	Distribution system	365,000
	Farm & irrigation equipment	685,000
	Land preparation & drainage control 1,000 acres	550,000
	Subtotal	$3,120,000
1983	Land purchase allowance 3,400 acres @ $100/acre	$ 340,000
	Temporary storage allowance 225 acre ft.	430,000
	Distribution system	200,000
	Farm & irrigation equipment	340,000
	Subtotal	$1,310,000
		$4,430,000 *
	Escalation -to 1971	285,000
	TOTAL ADDITIONS (ex. collection)	$5,700,000

* 1969 Dollars

TABLE 7

F. W. P. C. A. Waste Management Study

OPERATING COSTS

NORTHEAST OHIO REGIONAL SLUDGE DISPOSAL SYSTEM

(New 12" Pipeline)

		Costs in Thousands of Dollars			
Year	Tons/day	Transportation	Land Application	Management	Total
1974	128	208	253	100	561
1975	147	208	660	100	968
1976	158	210	705	100	1015
1977	168	212	751	100	1063
1978	180	216	796	100	1112
1979	191	219	842	100	1151
1980	225	243	888	100	1231
1981	240	261	934	100	1295
1982	255	282	1020	100	1402
1983	271	299	1038	100	1437
1984	286	313	1055	100	1468
1985	301	326	1073	100	1499
1986	310	335	1091	100	1526
1987	321	344	1108	100	1552
1988	331	352	1127	100	1579
1989	341	361	1145	100	1606
1990	351	369	1161	100	1630
1991	356	383	1180	100	1663
1992	362	390	1198	100	1688
1993	369	307	1216	100	1713
1994	374	406	1233	100	1739
1995	380	414	1251	100	1765
1996	386	422	1269	100	1791
1997	391	428	1287	100	1815
1998	398	438	1304	100	1842
1999	402	444	1322	100	1366
2000	409	452	1090	100	1642
		Sub-total			39,629 *
		Escalation to 1971			2,371
		TOTAL			$43,000

* 1969 Dollars

TABLE 8

F.W.P.C.A. Waste Management Study

UNIT DISPOSAL COSTS *

NORTHEAST OHIO REGIONAL SLUDGE DISPOSAL SYSTEM

(New 12" Pipeline)

Transportation and Disposal

Year	Capital Invested (mil. of $)	Capital Charges** (Thous. of $)	Operating Costs (Thous. of $)	Total Costs (Thous. of $	Annual Throughput (Tons of Dry Solids	Unit Cost ($/ton)
1974	9.1	711	595	1,306	46,700	27.97
1980	12.4	970	1,305	2,275	82,100	27.71
1985	14.4	1,126	1,589	2,715	109,900	24.70
1990	14.8	1,161	1,728	2,889	128,100	22.52
1995	14.8	1,161	1,871	3,032	138,700	21.86
2000	14.8	191	1,741	1,932	149,300	12.94
				Average for 27 years =		23.18

Collection (By Cities) - 27 Year Average

Years						
1974-2000	2.1	129	77	206	108,600	1.90

---

* 1971 Dollars

** @ 7.82% (25 year life - 6% interest)

Table 9 shows the projected sludge disposal costs including ash disposal, for the four waste-water treatment plants with filtration and incineration over the period 1974-2000. As indicated, additional capital would be required in 1974 and 1980 to provide the capacity to handle the increase in sludge production to the year 2000. For comparison purposes, the yearly expenditures have been discounted at 6% in order to obtain a total cost in 1971 dollars. A total discounted expenditure of $ 36.2 million over the twenty-six year period is indicated.

A similar cost presentation for the proposed regional sludge disposal system is shown in Table 10. Comparable costs for pipeline transport and disposal are $31.9 million. This gives an estimated present worth saving of $4.3 million, in spite of the fact that the bulk of Cleveland's filtering and incinerating equipment is already installed and does not appear in this analysis. This indicates that the savings would be substantially greater in cities where sizeable new investment is required.

TABLE 9

F.W.P.C.A. Waste Management Study

PROJECTED SLUDGE DISPOSAL COSTS

NORTHEAST OHIO REGION

VACUUM FILTRATION-INCINERATION

In Thousands of Dollars

Year	Tons/Day	Operating Cost(1)	Capital Investment(2)	Discounted Expenditures(3)
1974	128	1389	2671(4)	3,409
1975	147	1420	-	1,125
1976	158	1526	-	1,140
1977	168	1622	-	1,144
1978	180	1738	-	1,156
1979	191	1844	-	1,157
1980	225	2173	7420(5)	5,678
1981	240	2321	-	1,296
1982	255	2470	-	1,301
1983	271	2618	-	1,301
1984	286	2767	-	1,297
1985	301	2915	-	1,289
1986	310	3000	-	1,252
1987	321	3106	-	1,223
1988	331	3201	-	1,189
1989	341	3297	-	1,155
1990	351	3392	-	1,121
1991	356	3445	-	1,074
1992	362	3498	-	1,029
1993	369	3572	-	991
1994	374	3615	-	946
1995	380	3678	-	908
1996	386	3731	-	869
1997	391	3784	-	832
1998	398	3848	-	798
1999	402	3890	-	761
2000	409	3954	-	730
	TOTAL DISCOUNTED COSTS		=	$36,171,000
	Say			$36.2 Million

(1) @ $25/ton (plus 6% escalation to 1971 dollars)
(2) @ $35,000/daily ton of capacity (plus 6% escalation to 1971 dollars)
(3) Discounted @ 6 % rate to 1971 dollars
(4) Units sized for average rate of 32 tons/day installed at Westerly
Units sized for average rate of 40 tons/day installed at Canton
(5) Units sized for average rate of 80 tons/day installed at Rocky River
Units sized for average rate of 120 tons/day installed at Southerly

TABLE 10

F.W.P.C.A. Waste Management Study

PROJECTED SLUDGE DISPOSAL COSTS

NORTHEAST OHIO REGIONAL SLUDGE DISPOSAL SYSTEM

In Thousands of Dollars

Year	Operating Costs (1)	Capital Investment (1)	Discounted Expenditure (2)
1971	-	9084	9,084
1972	-	-	-
1973	-	-	-
1974	595	3307	3,276
1975	1026	-	813
1976	1076	-	804
1977	1127	-	795
1978	1179		784
1979	1231	-	772
1980	1305	-	772
1981	1373	604	1,104
1982	1486	-	783
1983	1523	1389	1,447
1984	1556	-	729
1985	1589	-	703
1986	1618	-	675
1987	1645	-	647
1988	1674	-	622
1989	1702	445	752
1990	1728	-	571
1991	1763	-	550
1992	1789	-	526
1993	1816	-	504
1994	1843	-	482
1995	1871	-	462
1996	1898	-	442
1997	1924	-	423
1998	1953	-	405
1999	1978	-	387
2000	1741	-	321

Total Discounted Costs (ex collection)	$29,635,000
Collection Discounted Costs	2,271,000
TOTAL DISCOUNTED COSTS =	$31,906,000
Say	$31.9 Million

(1) 1971 Dollars
(2) Discounted @ 6% rate to 1971 dollars

Dredgings Disposal System

The land disposal of the material dredged annually from the Cuyahoga River and Cleveland Harbor presents a somewhat different problem than the disposal of digested sludge.

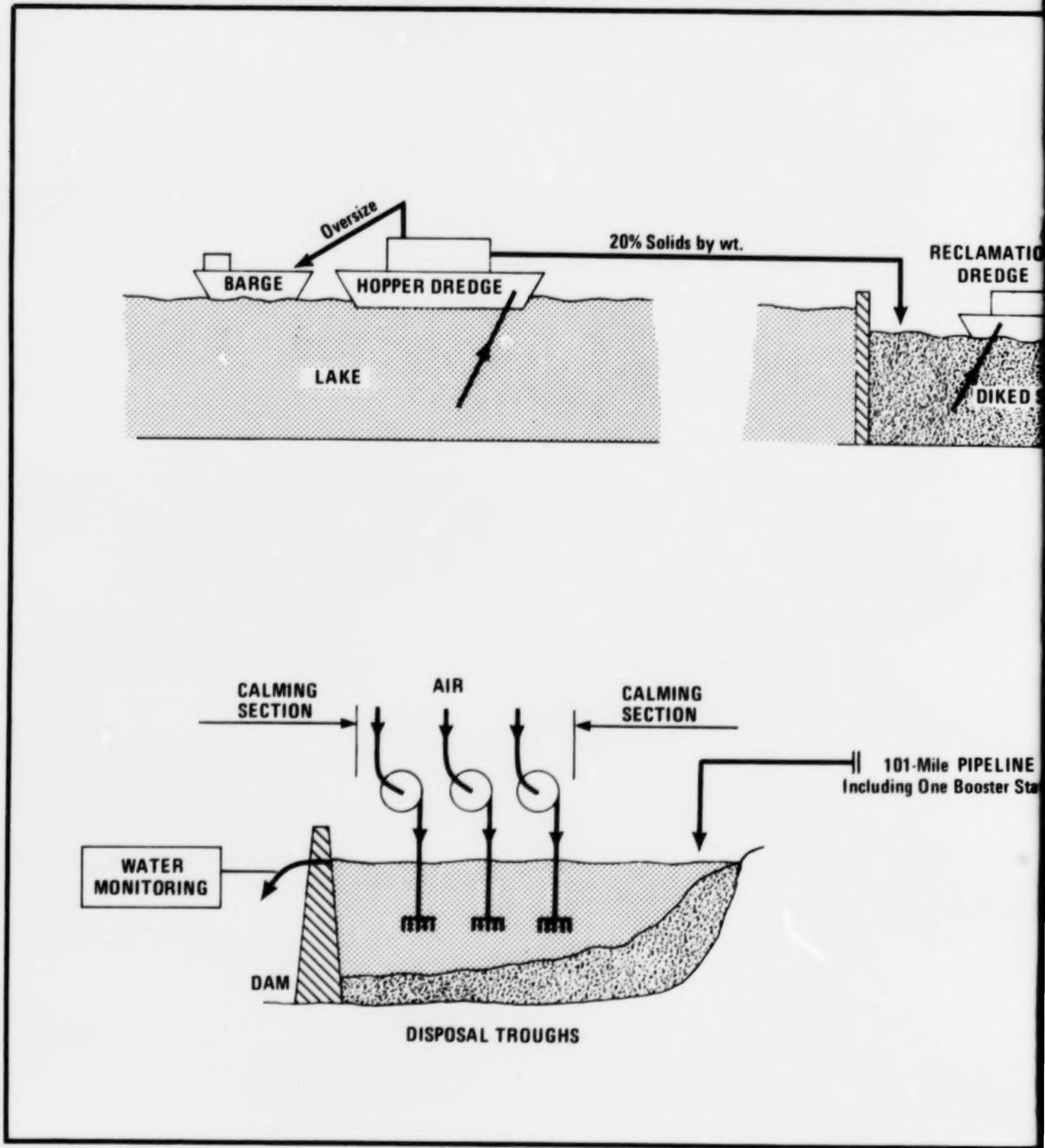
For example, the dredged solids are heavily polluted and therefore cannot be disposed of on land without some prior treatment. The system proposed to dispose of the dredgings consists of a collection and preparation terminal, a pipeline transportation system, a treatment process and, finally, disposal as land fill. The system is shown in Figure 17.

System Description. The recommended system for disposal of dredgings to a remote inland area has been designed to be compatible with the current dredging procedures used in the study region by the Corps of Engineers. At present, the Corps disposes of most of the dredged solids by open lake dumping. However, a pilot study is underway to examine the feasibility of disposal to diked areas, and to this end a 2 million cubic yard lagoon has been constructed on the Lake Erie shoreline at Cleveland.

This study proposes to use this lagoon for temporary storage of the dredged solids prior to transportation. Material is dredged from the river and harbor by hopper and clamshell dredges. By the use of screens and cyclones, the oversize (i. e. particles larger than 63 microns) is removed and transferred to a barge or scow for further treatment. The remaining dredgings are transported to the 2,000,000 cubic yard diked disposal area on the lake shore. The only change in the normal dredging practice employed by the Corps is one suggested by the Corps themselves, namely, the screening of stones and rocks at the dredge, prior to dumping in the lagoon.

F.W.P.C.A. Waste M

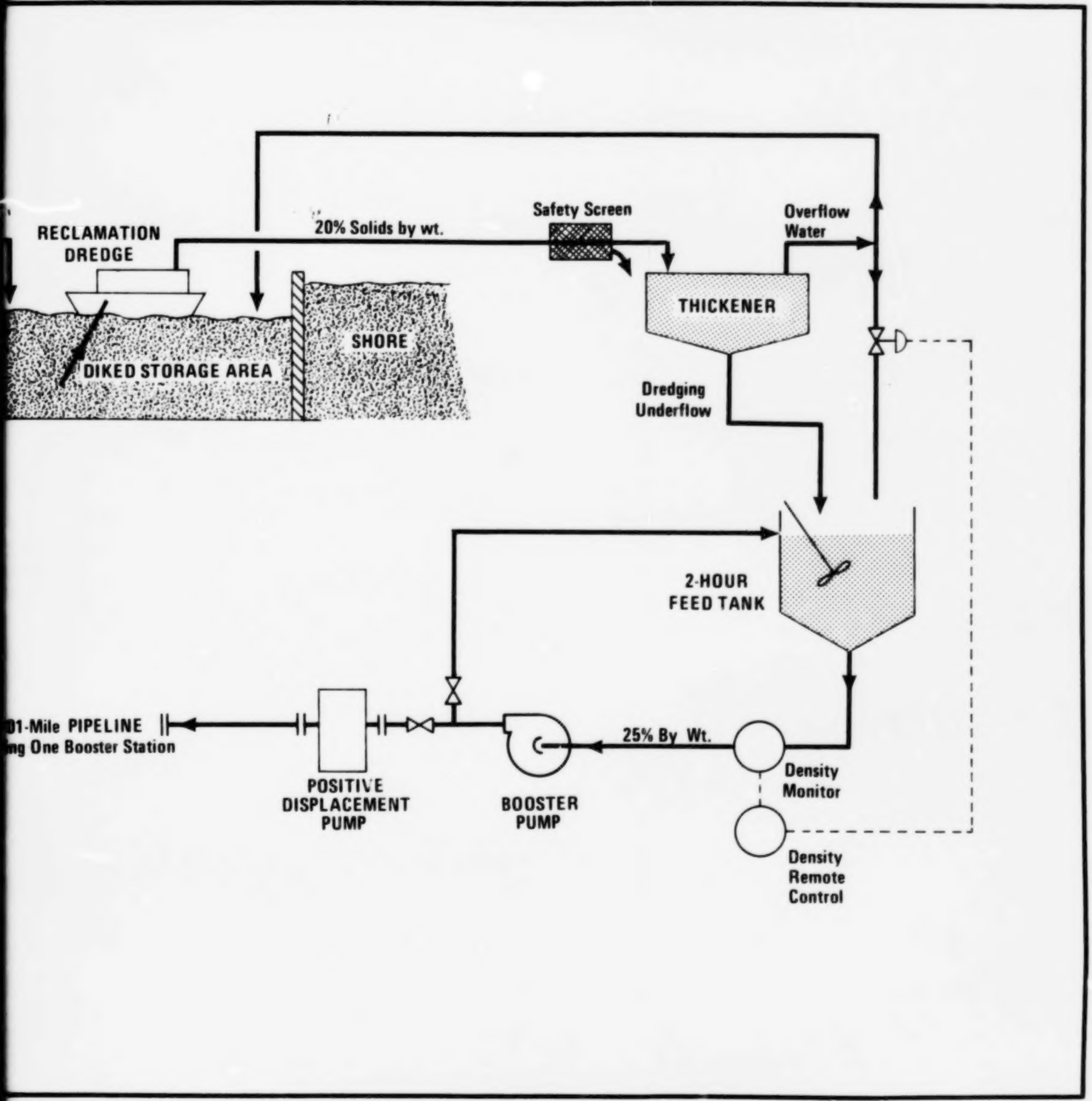
FACILITIES SUMMARY OF LAND DISPOSAL


Oversize
BARGE
HOPPER DREDGE
20% Solids by wt.
RECLAMATI
DREDGE
LAKE
DIKED
CALMING SECTION
AIR
CALMING SECTION
101-Mile PIPELINE
Including One Booster St
WATER MONITORING
DAM
DISPOSAL TROUGHS

A

Figure 17

ISPOSAL SYSTEM - MAINTENANCE DREDGINGS


RECLAMATION
DREDGE
20% Solids by wt.
Safety Screen
Overflow
Water
THICKENER
SHORE
DIKED STORAGE AREA
Dredging
Underflow
2-HOUR
FEED TANK
01-Mile PIPELINE
ng One Booster Station
POSITIVE
DISPLACEMENT
PUMP
BOOSTER
PUMP
25% By Wt.
Density
Monitor
Density
Remote
Control

B

A reclamation dredge, permanently stationed at the lagoon, removes the dredged solids from the diked lagoon and transports them through a safety screen (to remove debris), into a thickener on the lake shore. The thickener evens out the concentration variations in material from the dredge, which will average 20 weight percent solids, and provides the residence time necessary to thicken the dredgings to about 25 percent solids, a desirable concentration for pipeline transportation. (From laboratory rheological measurement, see Vol. III) From the thickener the slurry is fed to a 2-hour pump feed tank, where a final concentration adjustment is made by addition of part of the thickener overflow.

The bulk of the thickener overflow water is treated and returned to the lake. The oversize dredged material, which is inert and makes excellent fill, will be washed to remove pollutants, and the wash water will be treated and returned to the lake. It should be noted at this point that it is assumed that by the time the system is operational (1975), diked disposal areas for dredgings as recommended by the Corps of Engineers (5), will be generally used. Hence, the disposal lagoon and water treatment facilities will already be in existence.

At this point in the process, the dredgings are suitable for transportation to a remote disposal location. The method of transportation recommended by this study is by pipeline. This decision is based on an economic comparison between trucks, railroad and pipeline. The basis of the comparison was that the dredgings would be transported to the strip-mine areas in Southern Ohio, where they would be used as fill to level disturbed land. Farm and marsh lands located closer to the dredging area were discounted as possible disposal sites because of the difficulty in obtaining public acceptance of such a scheme.

Figure 18 shows the bases and results of the comparison. It should be noted that the costs presented for railroad and trucks do not include loading and unloading facilities. As noted from rheological considerations, a slurry of 25 percent solids was chosen for pipeline transportation. For the truck and rail cases, it is assumed that the dredgings would be thickened to 35 percent solids (the cost of which is not included). Centrifuging to a higher concentration has not been fully proven to be technically feasible, and was not considered in this study.

It can be seen from Figure 18, that in spite of the fact that costs for thickening and handling are not included for trucks and railroad, the pipeline system still offers a definite economic advantage.

The pipeline consists of 100 miles of 12-inch pipe and will require two pump stations. Mainline pumps will be positive displacement types and 1500 horsepower will be required at each pump station. The pipeline hydraulic gradient, showing pipewall allowable pressures and pump station locations is given in Figure 19.

It should be noted that it may be possible to take advantage of the fact that the sludge pipeline, as proposed, has a great deal of excess capacity in the early years. At the same time, it is possible that the pollutants in dredgings may be reduced significantly over the next 10 years or so. This combination of events suggests that the sludge pipeline could be used to transport dredgings in the early years. This possibility should be further investigated in future studies.

The dredgings, once transported to the strip mine areas, will be used to fill the troughs remaining from the mining of coal. In their natural state, dredgings are considered to be poor fill, since they have a high water re-

BASIS OF ECONOMICS O

PIPELINE

DESIGN BASIS
- 12-inch Diameter Pipe
- Pipe Velocity - 4-5 ft/sec.
- Route
  - 8 miles downstream
  - 35 miles suburban
  - 58 miles rural
- Dredgings at 25% solids by weight

CAPITAL INVESTMENT - including
- Pipe & Fittings
- Installation Cost
- Pump Stations
- Instrumentation and Control
- Indirects

ANNUAL CHARGES
- Capital Repayment over 25 years
- Interest Rate at 6 percent
- Annual Capital Repayment 7.82%
- Direct Operating Costs including
  - Power at 1 c KWH
  - Labor at $15,000/man
  - Supplies
  - Maintenance

TRANSPORTATION MODE
PIPELINE
RAILROAD
TRUCK

(60)

F.W.P.C.A. Waste Management Study

Figure 18

MICS OF TRANSPORTATION OF MAINTENANCE DREDGINGS

NORTHEAST OHIO REGION

BASIS: 101 Miles to Disposal

RAILROAD

DESIGN BASIS

- Unit Trains
- Two Trains required
- Car Capacity - 100 tons
- Loading and Unloading - 16 hours
- Round Trip - 2 days
- Dredgings at 35% solids by weight

CAPITAL INVESTMENT

- Tank Cars @$25,000 per car
- Loading and Unloading Facilities - not Included
- Capitalization of Rail Network - Included in Annual Operating Charge

ANNUAL CHARGES

- Capital Repayment over 25 years
- Interest Rate at 6 percent
- Annual Capital Repayment 7.82%
- Direct Operating Costs
  Railroad Supplies, Power,
  Capitalization and Return Trip
  Charged at 1.0 cent/ton mile
  Maintenance at 1.5 cent/car mile

TRUCK

DESIGN BASIS

- 24-hour per day Operation
- Truck Capacity - 6000 gallons
- Truck Availability at 80%
- Average Speed
  Downtown 15 mph
  Country 30 mph
- Loading and Unloading - 30 min.
- Dredgings at 35% solids by weight

CAPITAL INVESTMENT

- Truck and Trailer @ $35,000
- Loading and Unloading Facilities not Included

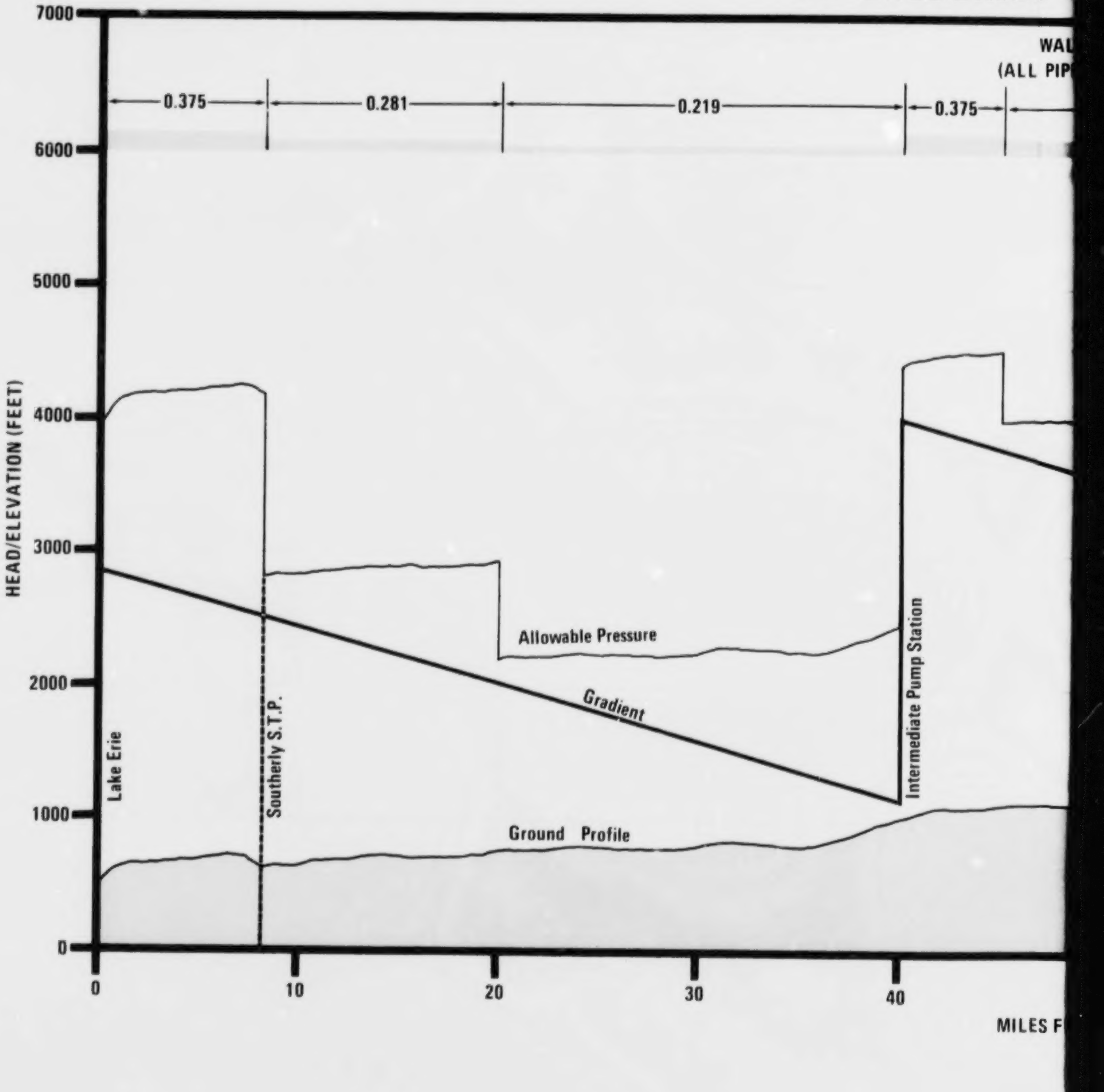
ANNUAL CHARGES

- Capital Repayment over 10 years
- Interest Rate at 6 percent
- Annual Capital Repayment 13.59%
- Operating Costs Including Fuel, Labor and Maintenance at $20 per hour.

PORTATION IODE	CAPITAL COST	OPERATING COST $/TON	TOTAL TRANSPORTATION COST $/TON
NE	0.86	0.58	1.44
OAD	0.43	2.95	3.38
	0.84	20.63	21.47

F.W.P.C.A. W

NORTHEAST OHI
GROUND PROFILE &
12" DREDGINGS

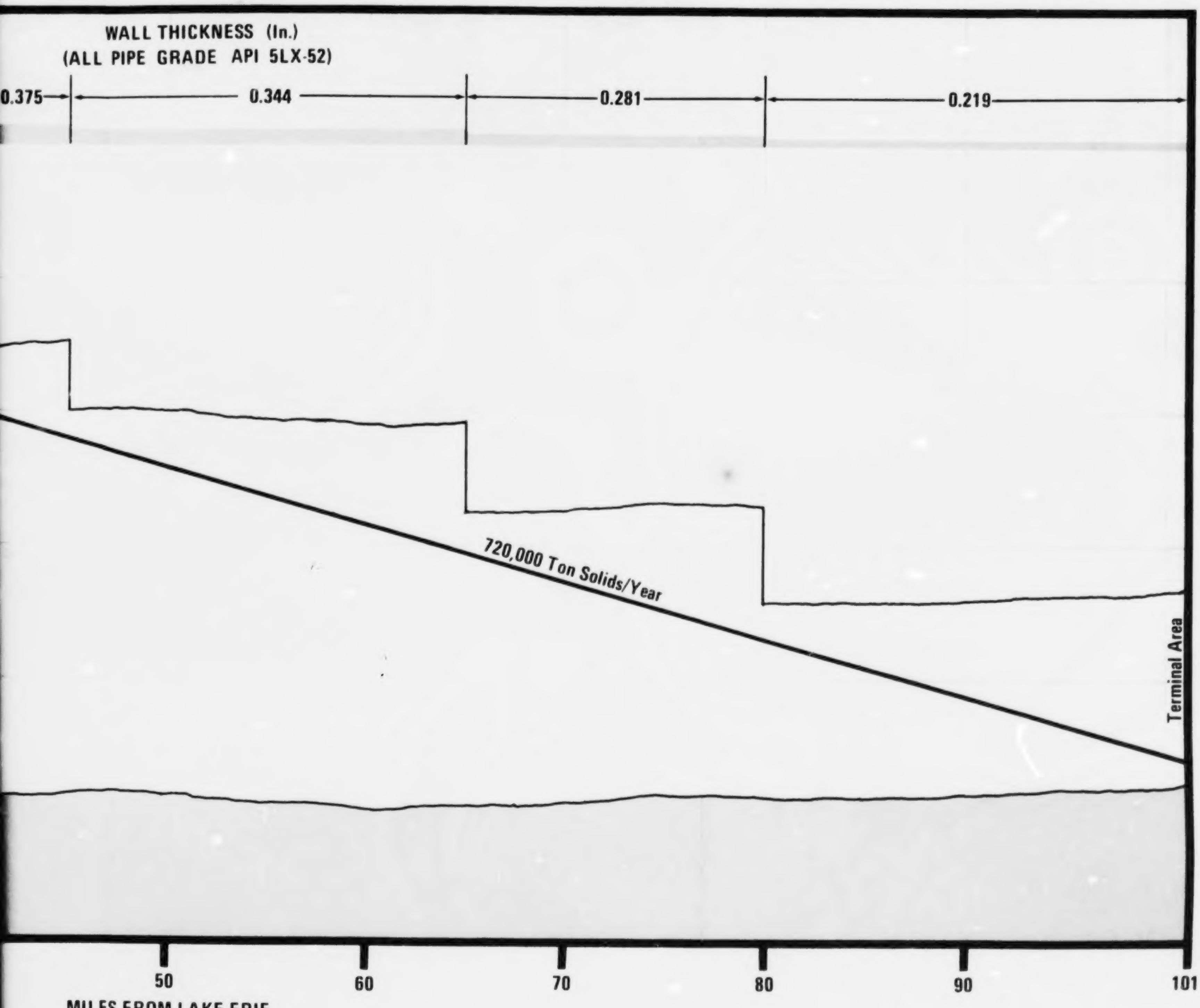


(61) A

F.W.P.C.A. Waste Management Study

Figure 19

AST OHIO REGIONAL SYSTEM ROFILE & HYDRAULIC GRADIENT DGINGS PIPELINE 25% SOLIDS



B

tention capacity, they are polluted, and they could cause odor and insect problems. Hence, it is necessary that the dredgings be treated prior to ultimate disposal, to ensure that there will be no transfer of pollution, and to improve the fill properties of the material.

The final method of disposal chosen for the full scale dredgings system will depend in part on the results of pilot studies conducted during the two year demonstration program. As one portion of this work, the program will examine the large scale effectiveness of aerobic stabilization as a treatment method. A previous study (7) has recommended aerobic stabilization as a suitable treatment process, and it is expected that the test program will confirm this.

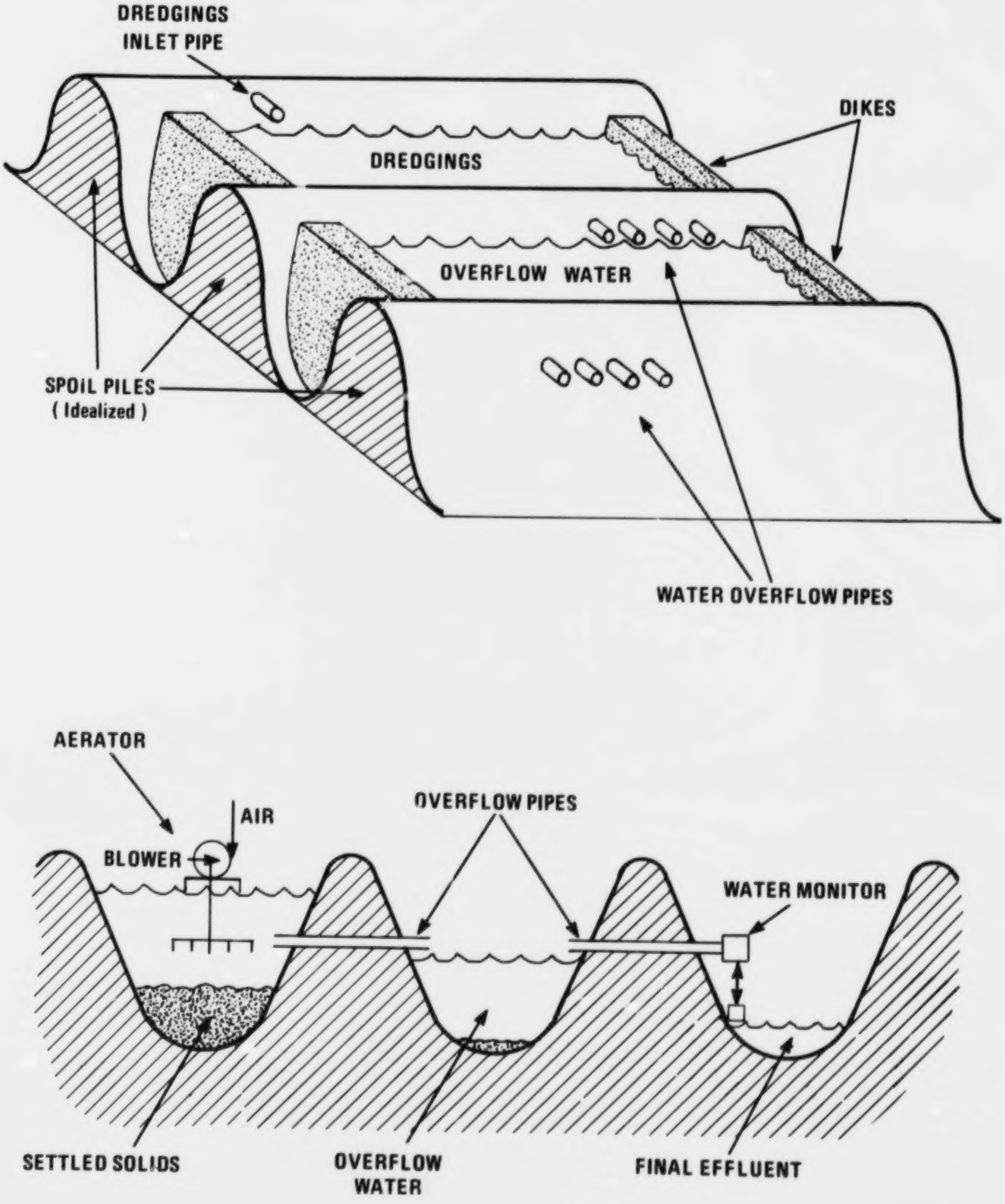
Treatment and disposal will be effected simultaneously as shown in Figure 17. Dredgings will be discharged to several systems of troughs which, as shown in Figure 20, are diked at both ends. In the first of these troughs the bulk of the solids are separated and stabilized by aeration. The air will be supplied by blowers which will float on the surface of the dredgings slurry. Separation will take place in the initial portion of the trough, and the aeration sections will provide a total capacity of 15 days supply of dredgings (33 million gallons). This will ensure the adequate residence time for stabilization. (7) The rest of the trough will be a calming section from which separated water will be withdrawn to a second trough.

The separated waters will be allowed to stabilize further for an additional 30 days or so in the second trough and then be transferred to a third furrow, where this will be repeated. It is expected that at this stage the water will be purified sufficiently to discharge to surface streams. This method of wastewater purification by lagoons has been used with great

Figure 20

F.W.P.C.A. Waste Management Study

DISPOSAL OF DREDGINGS IN SPOIL PILE TROUGH


DREDGINGS INLET PIPE
DIKES
DREDGINGS
OVERFLOW WATER
SPOIL PILES (Idealized)
WATER OVERFLOW PIPES
AERATOR
AIR
BLOWER
OVERFLOW PIPES
WATER MONITOR
SETTLED SOLIDS
OVERFLOW WATER
FINAL EFFLUENT

success (8) for the treatment of municipal waste waters, however, the technique will be investigated using dredgings, prior to installation of the commercial system.

The first trough will collect the stabilized solids and will eventually fill. The dredgings will then be fed to the second trough, and new troughs made available as water treatment lagoons.

The filled trough will be left to consolidate for a period of months and then will be covered by a thick layer of digested sludge so that a topsoil able to support vegetation will be developed.

Systems Costs. The capital cost and annual operating cost of the proposed dredgings disposal are shown in Table 11 and 12.

The capital cost of $10,300,000 (1971 Dollars) includes direct costs and all indirect costs such as engineering and procurement, but does not include any right-of-way costs for the pipeline. It is anticipated that this pipeline will follow the route of the 12-inch sludge pipeline, and that right-of-way will have already been purchased.

No allowance has been made for the cost of water treatment facilities at the collection terminal.

The estimated annual operating cost of the system is $1,400,000 (1971 dollars) which is equivalent to $1.95 per ton of solids. The manpower requirements for the system are shown in Table 13. It should be noted that maintenance of the system will be performed by an outside contractor, so that no manpower requirements are shown. Maintenance costs are included in the table of operating costs, Table 12.

Table 11

F. W. P. C. A. Waste Management Study
CAPITAL COSTS
NORTHEAST OHIO REGION
PROPOSED DREDGINGS DISPOSAL SYSTEM

Throughput: 720,000 dry tons/year

ITEM		COST (DOLLARS)
COLLECTION TERMINAL		
Reclaim Dredge	$	181,000
Tankage, thickener, agitators, etc.		238,000
Miscellaneous (safety screens, piping etc.)		125,000
Installation		456,000
Sub-Total		1,000,000
PIPELINE		
Pipe and Fittings	$	2,820,000
Pipeline Installation		2,790,000
Pump Stations (Installed)		1,580,000
Sub-Total	$	7,190,000
DISPOSAL TERMINAL		
Earth Moving Equipment	$	120,000
Pumps, etc.		70,000
Land Preparation		800,000
Miscellaneous (water monitoring, etc.)		150,000
Sub-Total	$	1,140,000
BUILDINGS		
Lab., office, change rooms, etc.	$	170,000
LAND PURCHASE		
200 acres @ $100/acre		200,000
Sub-Total	$	9,700,000 *
Escalation - to 1971		600,000
TOTAL CAPITAL COST	$	10,300,000

* 1969 Dollars

TABLE 12
F. W. P. C. A. Waste Management Study
OPERATING COSTS
NORTHEAST OHIO REGION
PROPOSED DREDGINGS DISPOSAL SYSTEM

ITEM		ANNUAL COST (DOLLARS)
Labor		
Reclaim dredge		$ 186,000
Preparation plant		40,000
Pump stations		78,000
Disposal Terminal		52,000
	Sub-Total	$ 356,000
Dredge Operation		375,000
Power		150,000
Land Preparation		180,000
Water Monitoring		50,000
Maintenance & Supplies		
Charged at 2% of Capital		198,000
	Sub-Total	$ 1,309,000 *
Escalation - to 1971		91,000
TOTAL ANNUAL OPERATING COST		$ 1,400,000
UNIT OPERATING COST ($/Ton Solids)		$1.95

* 1969 Dollars

TABLE 13

F. W. P. C. A. Waste Management Study
OPERATING LABOR REQUIREMENTS
NORTHEAST OHIO REGION
PROPOSED DREDGINGS DISPOSAL SYSTEM

SERVICE	No. REQUIRED	ANNUAL SALARY ($) * (7)
Dredge Operation		
Captain	1	16,000
Asst. Engineer	4	11,000
Operators	4	11,500
Launch & Pipeline	4	10,000
Deckhand	4	10,000
Preparation Plant		
Operator	4	10,000
Pump Stations		
Chief Engineer	1	16,000
Engineer	1	12,000
Operator	5	10,000
Disposal Terminal		
Engineer	1	12,000
Equipment Operators	2	10,000
Laborers	2	10,000

* 1969 Dollars

Assuming a capital payout of 25 years and interest on capital at 6%, the disposal cost is $3.05 per ton of solids or $1.91 per cubic yard of dredgings. This figure excludes the cost of the actual dredging operation. The Corps of Engineers has published(5) estimates of the cost of dredging and of disposal to diked areas for this specific case which are $0.79 per cubic yard (or $1.27 per ton of solids). Thus, the total disposal costs amount to $4.32 per ton of solids ($2.70 per cubic yard).

Comparison with Existing Disposal Methods. The Corps of Engineers(5) has presented the costs of open lake and diked area disposal for the specific case under study. The total disposal costs (capital plus operating) are compared with those for the proposed disposal system in Table 14.

The costs for disposal on land located 100 miles from Lake Erie are higher than those given by the Corps (i.e. $4.32 per ton versus $1.33 to $3.22 per ton). The system does, however, offer an alternative solution to what has now become a sensitive problem, inasmuch as safe disposal on land (after aerobic stabilization) will remove any apprehensions regarding the long term effects of lake disposal. Further, if a disposal site nearer the dredgings sources could be found, land disposal would be more attractive. Higher throughputs, of course, would make the pipeline disposal system more economical. For example, doubling the tonnages used in this analysis would make the pipeline system approximately equal to the costs of disposal to diked areas.

TABLE 14

F. W. P. C. A. Waste Management Study

ECONOMIC COMPARISON OF PROPOSED DREDGINGS DISPOSAL SYSTEM WITH PRESENT METHODS - NORTHEAST OHIO REGION

	Total Disposal Costs		
	Proposed System	Open-Lake Disposal *	Disposal to Diked Areas *
$/ton solids	$ 4.32	$ 1.33	$ 3.22
$/cubic yard **	2.70	0.83	2.00

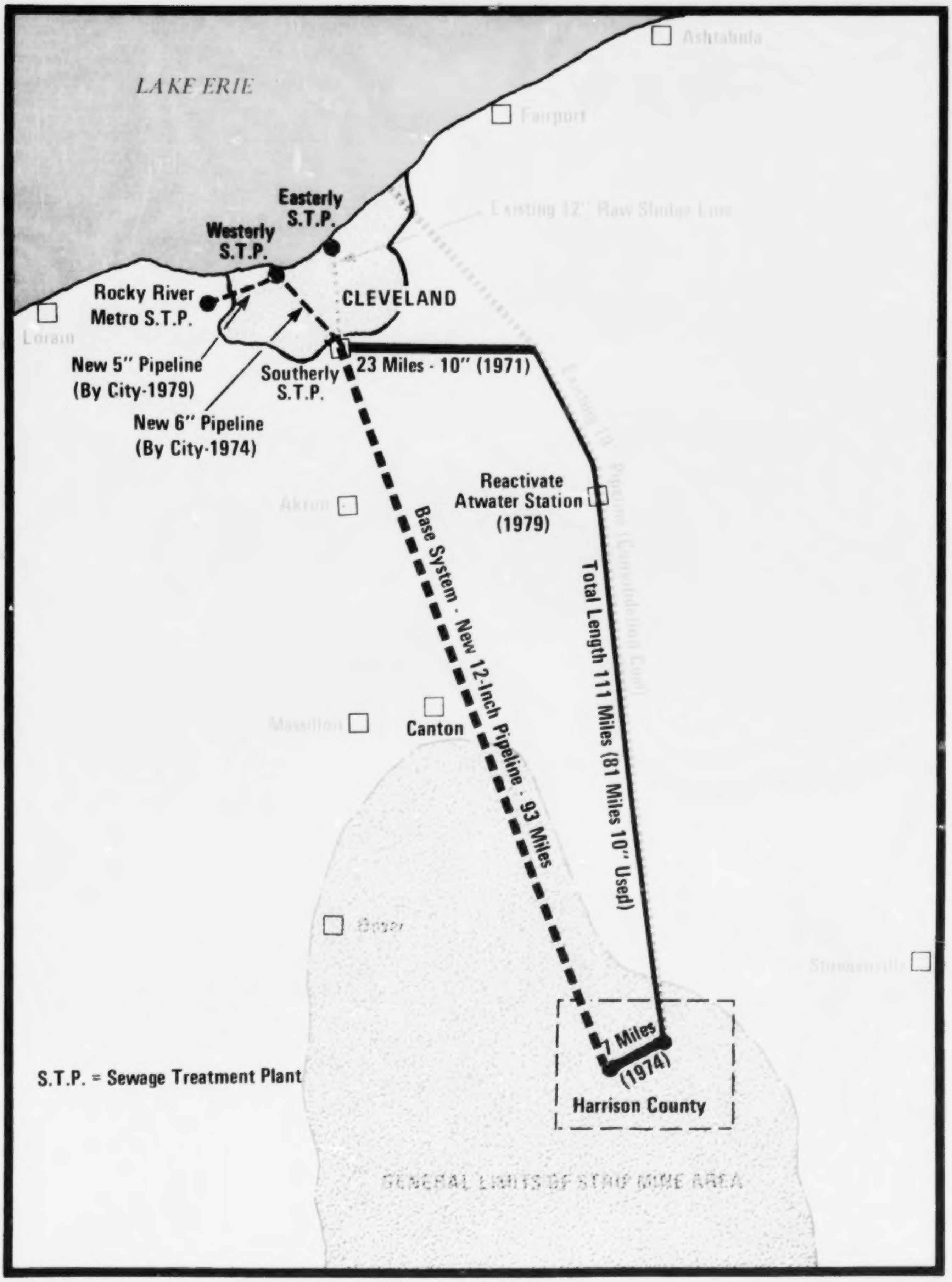
* "Dredging and Water Quality Problems in the Great Lakes", Corps of Engineers, March 1969 (escalated to 1971 costs @ 6%).

** Assuming 1 cubic yard contains 1250 lbs. of solids.

Figure 21

F. W. P. C. A. WASTE MANAGEMENT STUDY

ALTERNATE LAND DISPOSAL SYSTEM



LAKE ERIE
Ashtabula
Fairport
Existing 12" Raw Sludge Line
Easterly S.T.P.
Westerly S.T.P.
Rocky River Metro S.T.P.
CLEVELAND
Lorain
New 5" Pipeline (By City-1979)
New 6" Pipeline (By City-1974)
Southerly S.T.P.
23 Miles - 10" (1971)
Existing 10" Pipeline (Consolidation Coal)
Reactivate Atwater Station (1979)
Akron
Base System - New 12-Inch Pipeline - 93 Miles
Total Length 111 Miles (81 Miles 10" Used)
Massillon
Canton
Dover
Steubenville
7 Miles (1974)
Harrison County
S.T.P. = Sewage Treatment Plant
GENERAL LIMITS OF STRIP MINE AREA

ALTERNATIVE SLUDGE DISPOSAL SYSTEM
EXISTING 10-INCH PIPELINE

As noted earlier, Cleveland is in a very unique position in that an existing and presently unused 10-inch pipeline runs from about 20 miles east of Cleveland, southerly to the Harrison County disposal area. The line belongs to Consolidation Coal and was used for six years to successfully transport coal slurry. Due to its close proximity to both Cleveland and the disposal site, the possibility of using this line for sludge transport warranted consideration. As an initial step, preliminary discussions were held with Consolidation Coal and the parent company, Continental Oil Company, to explore the concept with them. Conoco indicated that they were very interested and would like to explore the possibility further. Although the existing coal pipeline is subject to a lease agreement until November 1974 during which time it could be requested that the line be returned to coal service, it is felt that this could be resolved, especially since it is very unlikely that the line would ever be used for coal service again.

The results of the analysis indicate that use of the existing line could be quite attractive, since the initial risk capital is much less than with a new 12-inch system -- $4.5 million versus $9.1 million. Although average unit transport and disposal costs over the system life will be slightly higher than with a new 12-inch system due to economy of scale, they are still well below the cost of filtering and incinerating the same tonnages, as shown later in this section.

The alternative Land Disposal System is shown in Figure 21. Indicated on the figure are the additional facilities required in order to utilize the existing 10-inch coal pipeline. It should be noted that the 12-inch system includes more cities and represents a higher throughput than that shown with use of the 10-inch Consolidation Coal line. Maximum tonnage in the 10-inch system is 78,800 tons per year as compared to

149,300 with the 12-inch system. The ability to concentrate would, of course, increase this capacity significantly. This should be investigated in any event.

For this system it is assumed that all sludge would be available centrally from the Southerly sewage treatment plant, near Cleveland's city border. A new 1250 horsepower pump station would be constructed at this point plus a 23-mile 10-inch pipeline easterly to the existing 10-inch line. This pump station and pipeline would be installed in 1971 for initial operation in 1972. This single pump station is adequate for the throughputs in the system up to 1979. The land disposal scheme would be as described previously for the 12-inch system.

The major system addition following the initial construction would be for irrigation and sprinkling equipment in 1974. Also in 1974 money is included for construction of a 7-mile 10-inch pipeline at the terminus of the existing line to permit disposal in another area. If suitable disposal sites could be located nearer to the existing pipeline, the length of this extension could be reduced. The only other system expansion is in 1979 when throughputs require that the existing Atwater Station be re-activated. At this time, the land disposal system is also expanded to meet the projected 1985 tonnages.

It has been assumed that the City of Cleveland would install a feeder line from Westerly to Southerly in 1973 for operation in 1974. Costs are not included for this line. Approximately 150 horsepower are required plus 8 miles of 6 inch pipeline which are estimated to cost $545,000 (1971 dollars). No other collection lines are required.

Regarding land requirements, for the first two years the total acreage required would be less than 1,000 acres.

The ultimate acreage required with the irrigation and sprinkling disposal method may total 5,000 acres.

The 10-inch system has been evaluated on the basis of expanding up to the year 1985 and maintaining a level throughput after that point, since the 1985 Cleveland tonnages represent roughly the economic capacity of the 10-inch system. The possibility of concentrating the sludge still exists and, if feasible, would provide for significant increases in the system capacity (A 3.5% concentration by weight was used in the analysis). Any contract with Cleveland should be written so that the tariff is a function of concentration as well as tonnage.

Table 15 shows the total costs required for a two year demonstration using the existing 10-inch pipeline. Table 16 shows direct operating costs for the demonstration. It is assumed that payment for the existing line would be made at the successful conclusion of the demonstration. As shown, total demonstration costs would be \$6.2 million or \$4.6 million less than the \$10.8 million required for the new 12-inch system. Required later additions to the system and estimated costs are presented in Table 17.

Following the demonstration, depending on the institutional management arrangement, the existing 10" pipeline would be purchased and become a permanent part of the land disposal system along with the required lands. In order to provide the necessary background data with which to evaluate the worth of the Consolidation Coal line, Table 18 is presented. In this analysis it was first assumed that the revenues accruing to the 10-inch system would be generated by applying the identical transport rates (\$/ton) as were required for the new state owned 12-inch system. These rates were then applied to the tonnages projected for

TABLE 15

F. W. P. C. A. Waste Management Study

TOTAL COSTS

TWO YEAR DEMONSTRATION PROJECT

(Using Existing 10 inch Pipeline*)

CAPITAL COSTS:		COST
Pipeline - 23 Miles of 10"		$ 1,500,000
Pump Station - 1300 Installed HP		570,000
Right-of-Way		380,000
Lagoon System and Irrigation Plots		
Lagoon System		
- 27 acres of lagoons and 5 miles of 10" feeder	855,000	
- loading and spreading equipment	230,000	
	$ 1,085,000	
Irrigation Plots		
- land preparation (200 acres) including drain tiles and stream protection	110,000	
- distribution sprinkler system	320,000	
- farm equipment and maintenance garage	75,000	
	$ 505,000	
Environmental Control		
- water monitoring equipment	50,000	
- laboratory facilities	130,000	
	$ 180,000	
Total Lagoon and Irrigation		1,770,000
Escalation**		280,000
TOTAL CAPITAL COSTS		$ 4,500,000
TOTAL DIRECT OPERATING COSTS***		1,700,000
TOTAL DEMONSTRATION COST		$ 6,200,000

* Cost of existing line purchase excluded - paid for after demonstration

** From 1969 to 1971 Dollars

*** Two year total -- See Table 16

TABLE 16

F. W. P. C. A. Waste Management Study

DIRECT OPERATING COSTS*
TWO YEAR DEMONSTRATION PROJECT
(Using Existing 10-inch Pipeline)

ITEM				
Transportation				
Power, labor and supplies			$	460,000
Lagoon System and Irrigation Plots				
Lagoon maintenance	$	65,000		
Trucking operation		120,000		
Farm operation		180,000		
Water monitoring		25,000		390,000
Development Program				
Transportation and land application	$	160,000		
Agricultural support		100,000		260,000
System Management				500,000
Escalation **				100,000
TOTAL OPERATING COSTS			$	1,710,000
		Say	$	1,700,000

*Excludes costs for leasing existing 10" pipeline
**From 1969 to 1971 Dollars

TABLE 17

F.W.P.C.A. Waste Management Study

ADDITIONS AND COSTS

NORTHEAST OHIO SLUDGE DISPOSAL SYSTEM

(Using Existing 10-inch Pipeline)

Year Added	Item	Capital Cost
COLLECTION (By Cities)		
1973	Westerly Feeder - 150 HP plus 8 mile 6" pipeline	$ 515,000
TRANSPORTATION		
1974	7 miles 10-inch pipeline at terminal	325,000
1979	Reactivate Atwater Station	100,000
	Subtotal	$ 425,000
LAND DISPOSAL		
1974	Land purchase allowance 3300 acres @ 100/acre	330,000
	Temporary storage allowance 225 acre feet	430,000
	Distribution system	200,000
	Farm & irrigation equipment	615,000
	Land preparation & drainage control 1,000 acres @$550/acre	550,000
	Subtotal	$2,125,000
1979	Land purchase allowance 1700 acres @ $100/acre	170,000
	Temporary storage allowance 110 acre feet	210,000
	Distribution system	120,000
	Farm & irrigation equipment	120,000
	Subtotal	$ 620,000
	Escalation*	230,000
	TOTAL ADDITION (ex. collection)	$3,400,000

* From 1969 to 1971 Dollars

the 10-inch system to calculate revenues.

The difference between these annual revenues and the annual costs of the 10-inch system (capital charges and direct operating costs) would be immediately available as payment for use of the existing 10-inch line. As shown in Table 18 these costs have been calculated and then discounted at 6 percent. This results in a present worth difference of about $1.4 million. However, that portion of the system contemplated for use in the project is worth more than this figure. The actual payment, of course, is a matter of negotiation between the parties and this report does not presume to set that price. It should be noted that an incremental increase in rate of $1.00 per ton is equivalent to a present value (@ 6%) of $844,000.

TABLE 1

F.W.P.C.A. Waste Ma

EVALUATION OF WORTH OF UTIL

(1971 Dollars

Year	Tons/Year(1)	Investment	Operating Costs	Amortization(2) (w/int. @ 6%)
			Thousands	of Dollars
1971		4,500		
1972	39,400		484	352
1973	40,200		612	352
1974	46,700	2,600	620	352
1975	48,200		1,037	555
1976	48,900		1,046	555
1977	50,000		1,055	555
1978	50,700		1,064	555
1979	52,200	800	1,089	555
1980	62,800		1,213	618
1981	66,100		1,251	618
1982	69,400		1,285	618
1983	72,600		1,328	618
1984	75,600		1,367	618
1985	78,800		1,088	618
1986	78,800		1,087	618
1987	78,800		1,088	618
1988	78,800		1,087	618
1989	78,800		1,088	618
1990	78,800		1,087	618
1991	78,300		1,088	618
1992	78,800		1,087	618
1993	78,800		1,088	618
1994	78,800		1,087	618
1995	78,800		1,088	618
1996	78,800		1,087	618
1997	78,800		1,088	266
1998	78,800		1,087	266
1999	78,800		1,088	266
2000	78,800		1,087	63
TOTAL	1,983,600		30,851	15,198

(1) Includes sludge only from Cleveland's sewage treatment plants:
Only Southerly served for years 1972-1973
Westerly added in 1974

(2) 25 year amortization period

(3) Note that an incremental increase in rate of $1.00/ton is equivalent to a present value (@ 6%) of $844,000.

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TABLE 18

Waste Management Study

H OF UTILIZING EXISTING 10" LINE

71 Dollars)

rtization(2) nt. @ 6%)	Total Annual Cost	Revenue		$ to Purchase 10"		Discount Factor
		$/ton(3)			Disc. @ 6%	
rs			Thousands of Dollars			
						1.0000
2	836	29.90	1,178	342	323	.9434
2	964	32.49	1,306	342	304	.8900
2	972	27.97	1,306	334	280	.8396
5	1,592	37.17	1,792	200	158	.7921
5	1,601	35.45	1,734	133	99	.7473
5	1,610	34.21	1,711	101	71	.7050
5	1,619	32.71	1,658	39	26	.6651
5	1,644	31.58	1,648	4	3	.6274
8	1,831	27.71	1,740	(91)	(54)	.5919
8	1,869	26.75	1,768	(101)	(56)	.5584
8	1,903	26.89	1,866	(37)	(19)	.5268
8	1,946	25.68	1,864	(82)	(41)	.4970
8	1,985	25.69	1,942	(43)	(20)	.4688
8	1,706	24.70	1,946	240	106	.4423
8	1,705	24.24	1,910	205	86	.4173
8	1,706	23.64	1,863	157	62	.3936
8	1,705	23.18	1,827	122	45	.3714
8	1,706	22.71	1,790	84	29	.3503
8	1,705	22.55	1,777	72	24	.3305
8	1,706	22.51	1,774	68	21	.3118
8	1,705	22.26	1,754	49	14	.2942
8	1,706	22.10	1,741	35	10	.2775
8	1,705	22.01	1,734	29	8	.2618
8	1,706	21.86	1,723	17	4	.2470
8	1,705	21.71	1,711	6	1	.2330
6	1,354	16.64	1,311	(43)	(9)	.2198
6	1,353	16.54	1,303	(50)	(10)	.2074
6	1,354	16.55	1,304	(50)	(10)	.1956
8	1,150	12.94	1,020	(130)	(24)	.1846
8	46,049	24.20	48,001	1,952	1,431	

B

INSTITUTIONAL MANAGEMENT CONSIDERATIONS

Need for a Regional Approach

The successful implementation of a land disposal system to accommodate the safe and useful disposal of sewage treatment plant sludge and dredging spoils, requires imaginative thinking and a high degree of cooperation on the part of all public authorities and private interests involved. The sheer volume of the wastes, the physical nature of the material, and the requirements for informing the general public of the beneficial aspects of the recommended disposal scheme impose serious demands in the formulation of the disposal system. However, it is similar in some respects to other regional service problems such as water supply, flood control, transportation, and solid waste disposal, none of which are respectors of jurisdictional boundaries. They are essentially regional in nature, affecting both urban and rural areas. The land disposal of water-borne wastes differs mainly in that large disposal areas are required. Acquiring title or long-term application rights for private lands or obtaining State or Federal lands for disposal purposes is a major consideration.

The application of the regional approach to the solution of metropolitan problems is recent and is undergoing an evolutionary development. The major factor which has encouraged this trend to the regional approach is the increased number of alternatives which become available with a regional approach and the resulting economy of scale.

To be meaningful, the analysis and evaluation of the institutional management aspects of waste disposal schemes must be specific and practical. This approach was used in examination of the Northeast Ohio Waste Disposal Scheme. The involved federal, state, and city governments and private interests were personally contacted during the course of the study. The alternative organizing schemes presented in this section are intended to reflect the inputs from these groups and are felt to be workable plans for this specific application which is a digested sludge pipeline and disposal system. (Since the dredging line is a future installation, it is recommended that examination of the institutional management considerations for this line be delayed until after the sludge line is in operation). Before discussing these alternative schemes, some background on existing jurisdictional bodies in the Northeast Ohio region is needed. The two principal bodies are the Ohio Water Development Authority (OWDA) and the City of Cleveland.

The Ohio Water Development Authority

In Ohio, the first strong position regarding water pollution took place in 1951 with the passage of the Ohio Water Pollution Control Act. This Act created the Ohio Water Pollution Control Board which had the power to develop programs of pollution control, administer grants from Federal and State governments, and perform regulatory functions. In 1967, in response to the amended Federal Water Pollution Control Act, the Board was given responsibility of developing state anti-pollution programs, assignment of priorities of projects within the state to qualify for Federal construction grants, and approval of applications for state and Federal construction grants.

To provide a means of securing the substantial increase in state construction grant funding required to obtain the maximum Federal construction grants, the General Assembly of Ohio on March 7, 1968, passed an Act (House Bill No. 998, File No. 456) creating the Ohio Water Development Authority. The responsibilities of this Authority are to "preserve, upgrade, conserve, develop, utilize, and manage the water resources of the State, to prevent or abate the pollution of water resources, and to promote beneficial use of waters of the State by providing for the acquisition, construction, maintenance, repair and operation of water development projects." The Authority is empowered to provide finances for the acquisition or construction of the required projects by the issuance of water development revenue bonds and notes of the state, both of which are payable solely from rentals and other charges guaranteed by the municipalities to whom the service is furnished (i.e. through a tariff). The Authority is responsible for the fixing of rents and other charges for the use of services of water development projects necessary to pay the operating costs of maintenance, repair and operation of such projects, as well as to amortize for the bonds and notes and related interest charges. In addition, it is legally possible for the OWDA to purchase existing plant facilities and to let a private enterprise operate them. At present, the Authority has no operating personnel.

The authority is not limited by statutory bond ceiling limitations and can finance any required project in which the revenues from the services will amortize the capital cost and pay for the operating costs. With the approval of the Governor, it can receive construction grants from any Federal agency or other sources of funds. The OWDA can fund up to 70% of the project's cost with repayments up to 40 years. They can combine their funding with FWPCA grants. At present, however, the State of Ohio is only getting about $10 million per year from the FWPCA.

Besides offering a means to finance pollution control facilities, the Authority can also purchase land for rights-of-way, condemn property, construct facilities, operate directly or engage an organization to operate the facilities.

The City of Cleveland

Cleveland is highly interested in the possibility of a sludge disposal pipeline. Presently, bonds issued for city projects are written over a 25-year period with a current interest rate of 6.0 percent per year on the unpaid balance. Cleveland cannot, however, own and operate facilities outside its jurisdictional boundaries. In addition, Cleveland may have difficulty in entering into long-term contracts. The possibility of the city entering into a long-term contract is presently being investigated by the responsible officials in Cleveland.

System Institutional Management and Financing

There are four basic institutional management routes which may be utilized to carry out this venture. As already noted, there are two physical systems - (A) a new 12-inch and (B) a modification of the existing 10-inch line. For each of these systems there are two methods of financing--private and state. In all cases, it is recommended that the collection facilities (i.e. feeder pipeline) be provided by the respective cities and that the transportation and disposal system for the demonstration project be operated by a private concern. Under the new 12-inch system, it is assumed that the maximum federal contribution will be available.

These four schemes are discussed below:

(A) New 12-Inch System (See Figure 22)

A-1 State Owned

In this case the OWDA would issue $2.7 million in revenue bonds equivalent to 25 percent of the required $10.8 million.

F.W.P.C.A.

INSTITUTIONAL MANAGE

(New

DEMONSTRATION – 2 YEARS

OWDA Sponsors Project

- Obtains two year contract with Cleveland ($34/Ton) and issues $2.7 million revenue bonds
- Obtains $3.6 million development grant from Federal Government
- Obtains $4.5 million construction grant from Federal Government
- *Contracts with Consolidation Coal for operation of system and leases land from Consolidation Coal for the two-year demonstration
- Obtains right-of-way for the new pipeline
- Obtains agreement with Cleveland on required sludge characteristics

Capital Contribution Summary

Item	Amount	Source	
Physical plant (new)	$9.1 million	(2.7) Revenue Bonds – OWDA	25%
Operating Costs	$1.7 million	(4.5) Construction Grant – FWPCA	75%
		(3.6) Development Grant – FWPCA	
	$10.8 million		100%

* Consol may void the agreement after 2 years for the following reasons:
- Ground water pollution as a result of sludge application
- Excessive land requirements
- Local public dissatisfaction ... significant and documented

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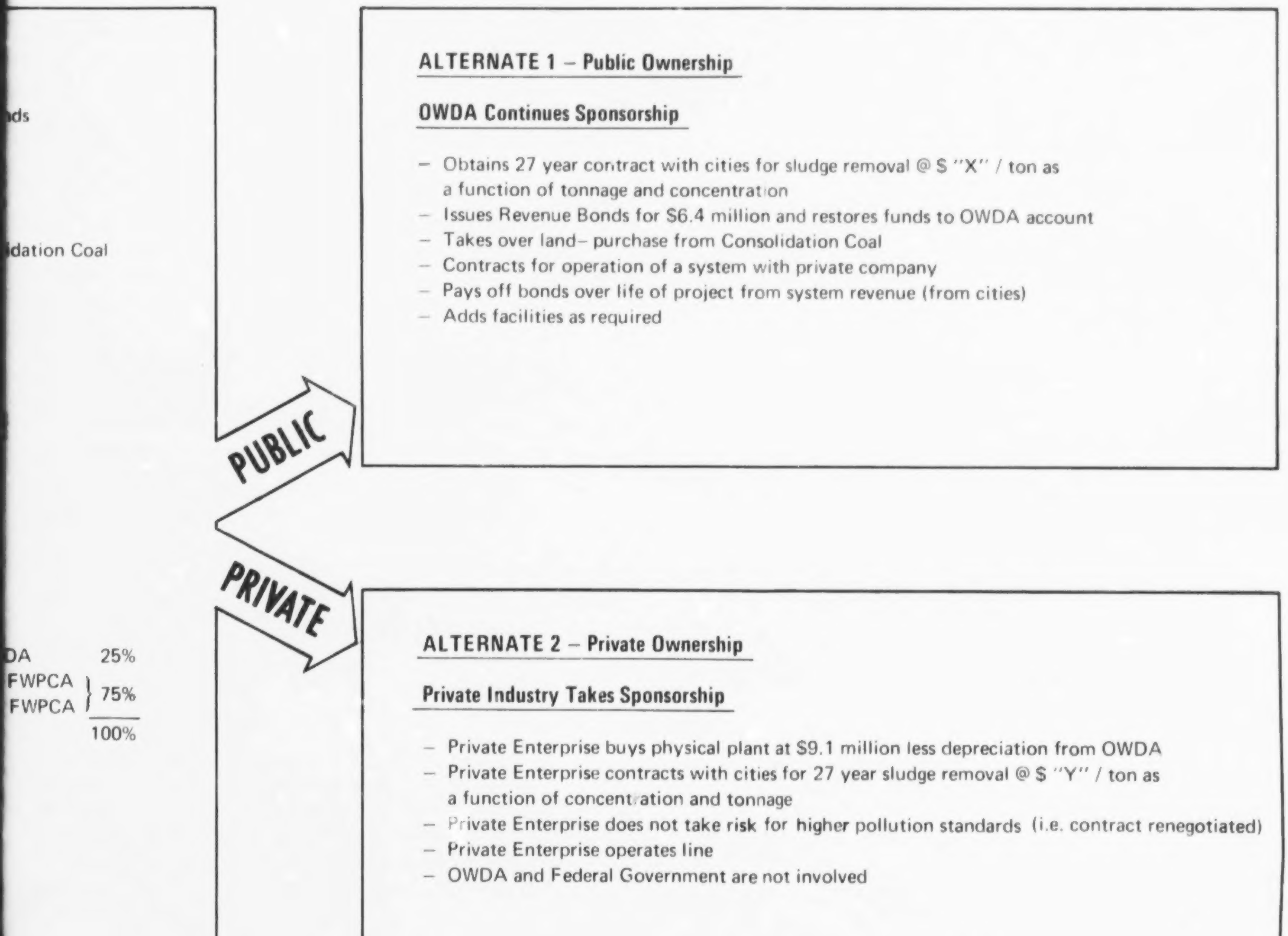
F.W.P.C.A. Waste Management Study

Figure 22

MANAGEMENT OF LAND DISPOSAL SYSTEM

(New 12-Inch Pipeline)

PLAN A



ds

dation Coal

DA 25%
FWPCA } 75%
FWPCA
100%

COMMERCIAL OPERATION – 27 YEARS

ALTERNATE 1 – Public Ownership

OWDA Continues Sponsorship

- Obtains 27 year contract with cities for sludge removal @ $ "X" / ton as a function of tonnage and concentration
- Issues Revenue Bonds for $6.4 million and restores funds to OWDA account
- Takes over land– purchase from Consolidation Coal
- Contracts for operation of a system with private company
- Pays off bonds over life of project from system revenue (from cities)
- Adds facilities as required

ALTERNATE 2 – Private Ownership

Private Industry Takes Sponsorship

- Private Enterprise buys physical plant at $9.1 million less depreciation from OWDA
- Private Enterprise contracts with cities for 27 year sludge removal @ $ "Y" / ton as a function of concentration and tonnage
- Private Enterprise does not take risk for higher pollution standards (i.e. contract renegotiated)
- Private Enterprise operates line
- OWDA and Federal Government are not involved

B

The City of Cleveland would sign a two-year contract with the OWDA for sludge removal. The Federal Government through the State would put up the remaining initial investment of about $6.4 million plus the first two years operating costs of about $1.7 million. The bulk of the federal money would come from the State of Ohio's federal allocation as a construction grant with the rest obtained from development grants. At the end of the two-year demonstration period, the state (OWDA) would take over the project from a financial standpoint and issue revenue bonds to cover the amortization of the remainder of the facility.

The major problem of this route is the difficulty of getting Federal, State and Municipal authorities together, especially the requirement for state funding of $2.7 million at the outset. This is necessary since the F. W. P. C. A. cannot fund more than 75% of the total costs of any demonstration project.

A-2 Private Ownership

Although private ownership, on the surface, is quite appealing, it has some serious economic drawbacks. A preliminary appraisal indicates that a private company would have to charge in excess of $35/ton in order to show a decent rate of return on investment. This is probably in excess of what the muncipalities would be willing to pay. This is a direct result of the higher "capital charges" which a private industry must build into a rate structure in order to allow for profit, federal and state income taxes and ad valorem taxes which a publicly-owned facility would avoid. For comparative purposes, typical capital charges for a public and privately held undertaking are as follows:

	Capital Charges as a Percent of Investment Average Year	
Item	Public	Private
Depreciation - 25 yrs.	4.0	4.0
Interest	3.0 1/	3.2 2/
Ad Valorem taxes	-	1.0
Profit	-	3.0 3/
Federal income taxes @ 50%	-	3.0
Total	7.0 %	14.2 %

1/ 1st year equals 6%, last year = 0%, avg. = 3%

2/ 1st year (assuming 80% debt) equals .8 (8.0) or 6.4% avg. = 3.2%

3/ 20% equity times 15% return on equity = 3.0%

As shown above, even on this rather conservative basis, private industry would require annual capital charges more than double that necessary for a public entity. For example, on a $9.1 million investment, private industry would require annual revenues of nearly $1.3 million whereas a publicly-owned system would require only $640,000 per year. The bulk of this difference, of course, is returned to the public through taxes; however, it still must be built into the rate charged to the municipality.

(B) Existing 10-Inch Consol Line (See Figure 23)

B-1 State-Owned

In this case, the Federal Government through the state would support the project during an initial proving period of two years, using the value of the existing Consolidation Coal line as part of the initial capital investment. The new federal investment would be a construction grant of \$2.2 million plus the first two years operating costs of about \$1.7 million. In this case, the OWDA would issue \$2.3 million in revenue bonds (25% of total cost) and again sign a two-year contract with Cleveland for sludge disposal. It is recommended that Consolidation Coal operate the facility and after a proving period of two years, be reimbursed for the used portion of the existing facility. As already noted, the value of the existing 10-inch line to this waste system would, of course, be negotiated. As an orientation figure, a tariff schedule of about \$2/ton in excess of that shown on Table 17 could justify a lump payment to Conoco of approximately \$3 million after the two-year proving period. The unit cost to the cities would, therefore, be about \$27/ton average over a 27 year period.

B-2 Private Ownership

This case assumes that Consolidation Coal (Conoco) would provide the risk capital and charge Cleveland a tariff for moving the sludge. The same consideration of high capital charges as noted in A-2 above applies to this case.

Figures 22 and 23, respectively, illustrate the conditions and steps necessary for institutional management alternates of the new 12-inch or utilization of the existing 10-inch system.

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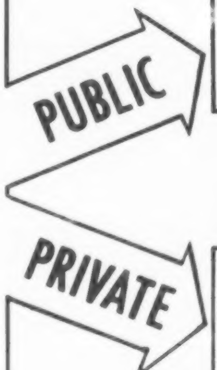
DEMONSTRATION – 2 YEARS

OWDA Sponsors Project

- Obtains two year contract with Cleveland ($29/ton) and issues $2.3 million in revenue bonds
- Obtains contingency contract with Consolidation Coal to purchase line after demonstration
- Obtains $1.7 million development grant from Federal Government
- Obtains $4.5 million construction grant from Federal Government
- *Contracts with Consolidation Coal for operation of system and leases land from Consolidation Coal for the two-year demonstration
- Obtains right-of-way for the new pipeline (23 miles)
- Obtains agreement with Cleveland on required sludge characteristics during two-year period



Capital Contribution Summary

Item	Amount	Source	
Physical plant (new)	$4.5 million	(2.2) Construction Grant - FWPCA	42%
Operating Costs	$1.7 million	(1.7) Development Grant - FWPCA	
Existing 10" line	$3.0 million **	(3.0) OWDA Contingency contract	33%
		(2.3) Revenue Bonds OWDA	25%
	$9.2 million		100%

* Consol may void the agreement after 2 years for the following reasons:

- Ground water pollution as a result of sludge application
- Excessive land requirements
- Local public dissatisfaction ... significant and documented
- Consol wants to take over system as a private enterprise

** For illustrative purposes only – actual price subject to negotiation between parties

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F.W.P.C.A. Waste Management Study

ıL MANAGEMENT OF LAND DISPOSAL SYSTEM

(Utilizing 10–Inch Consolidation Coal Line)

PLAN B

ıERCIAL OPERATION – 27 YEARS

LTERNATE 1 – Public Ownership

WDA Continues Sponsorship

- Obtains 27 year contract with cities for sludge removal @ $ "X" / ton as a function of tonnage and concentration
- Issues Revenue Bonds for $3.0 million** and excercises contingency contract with Consolidation Coal to purchase 10" line
- Issues Revenue Bonds for $5.2 million and restores funds to OWDA account
- Takes over land–purchase from Consolidation Coal
- Contracts for operation of system with private company
- Pays off bonds over life of project from system revenue (from cities)
- Adds facilities as required

ıLTERNATE 2 – Private Ownership

Consolidation Coal Takes Sponsorship

- Consolidation Coal buys physical plant $4.5 million less depreciation from OWDA
- Consolidation Coal contracts with city of Cleveland for 27 year sludge removal @ $ "Y" / ton as a function of concentration and tonnage
- Consolidation Coal voids contingency contract with OWDA and keeps 10" line
- Consolidation Coal does not take risk for higher pollution standards (i.e. contract renegotiated)
- Consolidation Coal operates line
- OWDA and Federal Government are not involved

B

COMMERCIAL OPERATION FROM OUTS

ALTERNATE 3 – Private Ownership

Consolidation Coal Sponsors Project

- *Consolidation Coal contracts with ci @ $ "Z" / ton as a function of conce
- Consolidation Coal invests necessary (including land)
- OWDA assists in obtaining required
- Consolidation Coal operates the line
- Consolidation Coal does not take ris (i.e. contract renegotiated)

* Consolidation Coal may void the co a reasonable notice period) and tak

- Ground water pollution as a result o
- Local and public dissatisfaction ... si

C

agement Study

Figure 23

F LAND DISPOSAL SYSTEM

lidation Coal Line)

B

udge removal @ $ "X" / ton as

and excercises contingency contract
line

and restores funds to OWDA account
tion Coal
ivate company
stem revenue (from cities)

.5 million less depreciation from OWDA
Cleveland for 27 year sludge removal
ion and tonnage
tract with OWDA and keeps 10" line
higher pollution standards

nvolved

COMMERCIAL OPERATION FROM OUTSET (No Demonstration)

ALTERNATE 3 – Private Ownership

Consolidation Coal Sponsors Project

- *Consolidation Coal contracts with city of Cleveland for 29 year sludge removal @ $ "Z" / ton as a function of concentration and tonnage
- Consolidation Coal invests necessary capital for pipeline and disposal system (including land)
- OWDA assists in obtaining required rights of way
- Consolidation Coal operates the line
- Consolidation Coal does not take risk for higher pollution standards (i.e. contract renegotiated)

* Consolidation Coal may void the contract at any time (giving City of Cleveland a reasonable notice period) and take a business loss for the following reasons:

- Ground water pollution as a result of sludge application
- Local and public dissatisfaction ... significant and documented

C

FUTURE WORK

The Northeast Ohio region, being in the unique position of have an unused pipeline in close proximity to the major sources of waste, has open to it a number of possibilities with regard to waste disposal. Although beyond the scope of this present study, some of these alternates merit investigation and will be discussed here as topics for future work.

Digested Sludge

Increased Concentration

The possibility of transporting a more concentrated sludge than 3.5 weight percent solids should be investigated. Currently, the losses in concentrating makes this approach unattractive. However, if in the future concentration can be more effectively and economically accomplished, the main pipeline could be either reduced in diameter from the 10 or 12-inch lines now proposed, thus reducing capital investment, as well as operating cost, or the capacity of the lines could be increased so as to accommodate other materials such as dredgings.

Burning Sludge with Power Plant Fuel

As an alternate to land disposal it may be possible to burn the digested sludge along with the normal fuel used for power generation. The sludge could be transported to Eastlake via the existing coal line once the 23-mile spur was built to connect Southerly to the coal line. The coal burn at the Eastlake Power Plant of Cleveland Electric Illuminating Company is about 4000 tons/day. As noted, the 1972 sludge volume for Cleveland is about 110 tons/day. This type of coal has been burned directly as a 66% weight slurry. If the 4000 tons/day of

East Lake coal were made up to a 66% weight slurry with sludge and then burned, about 75 tons/day of 3.5% sludge could be disposed of in this manner. The thermal penalty using a 66% weight concentrate coal fuel would amount to about $1,300/day. This penalty corresponds to about $18/ton sludge burned but does not allow any cost for equipment revisions which would be substantial. Higher concentrations would favorably and significantly change this picture. A detailed study investigating specific power and sewage plant combinations could prove fruitful.

Maintenance Dredgings

Maintenance dredgings could be incorporated into the digested sludge system in a number of ways.

For example, spare capacity is available in the proposed 12-inch sludge line during the early years of operation and this could be used to batch dredgings to the disposal site. The dredgings could readily be introduced into the system at Westerly, which is on the lake shore. Transportation to the mainline could be effected by a separate 8-inch line from Westerly to Southerly, or by installing a 12-inch collection line rather than the 6-inch sludge line proposed. This possibility is particularly attractive since, with the current drive to prevent further pollution of Lake Erie, the problem of disposal of polluted dredgings may be greatly reduced in the future.

If disposal of dredgings continues to present difficulties when the extra capacity in the 12-inch line is no longer available, the unused coal pipeline from Eastlake to Harrison County could be used to transport dredgings. Alternately, if this situation can be foreseen, the mainline could be installed as 16 or 18-inch diameter to provide the required capacity.

In any event, the extra cost of allowing for these contingencies should be fully evaluated prior to commencement of construction of the transportation system. Because of the number of options available, it is essential that the conditions of right-of-way purchase should include transportation of dredgings and other materials.

The installation of a pump station at the Eastlake Plant of Cleveland Electric Illuminating would permit fly ash slurry to be pumped to Harrison County for agriculture purposes. If the demonstration project goes ahead, pilot agricultural experiments to determine the worth of fly ash for land reclamation would be carried out.

Industrial Wastes

Before other industrial wastes can be safely and efficiently incorporated into the proposed disposal system, extensive survey and experimental work is required.

The location and magnitude of the specific wastes must be established, and their characteristics and the effect of these characteristics on the overall transportation and disposal scheme must be evaluated.

Such a program, if implemented in the near future, could be combined with the land disposal demonstration project to produce valuable information.

COASTAL REGION OPTION - OCEAN DISPOSAL

SELECTION AND DESCRIPTION OF STUDY REGION

The Atlantic Coast Megalopolis area, as defined in this study is shown in Figure 1. This megalopolis contains about 25 percent of the total U. S. population. Included in this area are the cities of Washington, Baltimore, Philadelphia, Newark, New York and Boston, all of which have populations in excess of a million people and most of which are highly industrialized. As with the Great Lakes megalopolis, the high density of people and industry has created serious waste disposal and pollution problems.

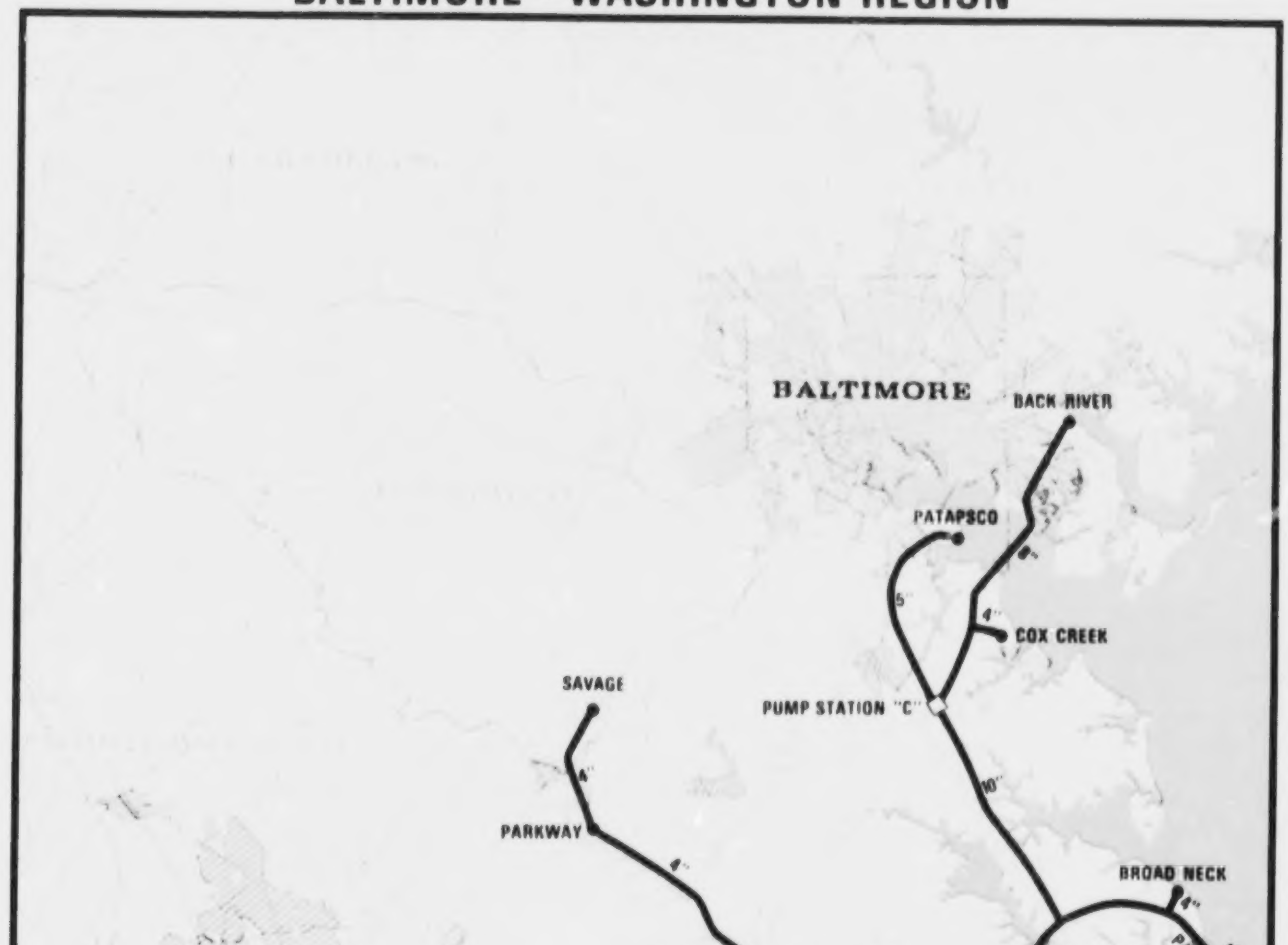
As discussed previously, development of a waste management concept for this megalopolis requires detailed analysis of a specific region within the area which is representative of the whole area in terms of type and magnitude of waste handling problems. The location chosen for specific case study is the Baltimore-Washington region, and is shown in Figure 24. The factors which led to the selection of this region are as follows:

- There is a specific and severe waste disposal problem in this region.(9) (10)
- The regional pollution problems are typical of those generally experienced in the Atlantic Coast Megalopolis area.
- The magnitude of the waste considered is such that effective regional disposal could result in economies of scale, and would significantly aid pollution control in the region.

Figure 24

F.W.P.C.A. Waste Management Study

LOCATION MAP - YEAR 2000
DIGESTED SLUDGE SYSTEM
BALTIMORE - WASHINGTON REGION


BALTIMORE
BACK RIVER
PATAPSCO
8"
5"
4"
COX CREEK
PUMP STATION "C"
SAVAGE
4"
PARKWAY
10"
4"
BROAD NECK
4"
16"
P/L to Outfall
BELAIR BOWIE
14"
4"
ANNAPOLIS
14"
SLUDGE PIPELINES
WASHINGTON
4"
ARLINGTON
4"
ALEXANDRIA
DIST. OF COLUMBIA
6"
4"
WESTGATE
4"
4"
POHICK
5"
LITTLE HUNT CREEK
PISCATAWAY
WESTERN BRANCH
CHESAPEAKE BAY
SCALE IN MILES
5 4 3 2 1 0
5
10

- It includes several cities and two states which magnifies the institutional problems.

- There already are working institutional relationships established between the cities and states that can serve as guides for formulating a new regional authority.

- The region contains suitable areas for disposal sites.

Thus, the selected region is consistent with the criteria for selection demanded by the system methodology discussed previously.

The basic difference between the Baltimore-Washington region and the Northeast Ohio region is that the coastal region has the option of either land or ocean disposal. Since the concept of land disposal has been thoroughly examined in the Northeast Ohio region, and the results of that study are directly applicable to Baltimore-Washington, or any other region, this section of the study will confine itself to ocean disposal of waste materials.

The waste of particular interest is digested sewage sludge. The disposal of maintenance dredgings, and the considerations regarding the inclusion of fly ash or water treatment plant sludge into a disposal system have been discussed in the land disposal case. The conclusions are directly applicable to this study, and will not be repeated here.

The projected volumes of digested sludge from the major waste-water treatment plants in this region, for the period from 1975 up to the year 2000 are given in Table 19.

TABLE 19

F.W.P.C.A. Waste Management Study

PROJECTED SLUDGE QUANTITIES
BALTIMORE - WASHINGTON REGION*

Dry Tons/Day

Treatment Plant	1975	1980	1985	1990	1995	2000
Dist. of Columbia	134	186	259	279	310	340
Arlington	15	19	23	24	26	27
Alexandria	12	17	22	25	29	32
Westgate	6	7	9	9	9	9
Pohick	11	22	34	44	54	64
Little Huntington Creek	3	4	6	7	8	10
Piscataway	8	13	19	23	27	31
Parkway	3	6	8	10	12	14
Belair-Bowie	4	6	9	11	12	14
Western Branch	9	13	18	21	23	26
Back River	76	107	143	156	169	182
Patapsco	17	31	47	59	70	81
Cox Creek	4	7	9	11	12	14
Savage	2	5	9	12	16	19
Annapolis	3	5	8	11	13	16
Broad Neck	4	6	10	12	15	17
TOTAL	311	454	633	714	805	896

* Includes both digested sludge and waste chemical sludge

GENERAL SCOPE

The disposal of sewage sludge to the ocean is practised at a number of cities in the Atlantic Coast area. The sludge is usually loaded into barges or tankers and is taken out to sea for distances of about 10 miles and dumped into the waters of the continental shelf. The city of Boston uses an ocean outfall pipeline for sludge disposal.

In applying the disposal methodology to ocean disposal, it becomes apparent that the long-term effects on the environment of these practices are not fully established. However, limited current information indicates that if sludge disposal to the waters of the continental shelf was adopted throughout the Atlantic Coast Megalopolis, sufficient water for dilution would not be available for all the sludge production by the year 2000, and pollution on a vast scale could result. Therefore, although it still may be possible for a portion of the total area to utilize the shelf for disposal, in this study, the requirement for safe disposal has been taken as being that the sludge is transported to the deep waters beyond the continental shelf.

Figure 24 is a map of the Baltimore-Washington region showing the locations of sixteen major sewage treatment plants which will exist in the year 1975. The relative positions of the plants lend themselves to a common disposal system. Any ocean disposal system for this region will consist essentially of two elements - a collection network and a bulk transportation system. In turn, the former will contain separate collection systems for the two distinct metropolitan areas of Baltimore and Washington.

It has been shown in the Northeast Ohio Study that collection is most economically accomplished by using pipelines. For the bulk transportation system two alternates are available - ocean going vessels and pipeline.

In the following sections, the cost of transporting sludge 80 miles out to sea, beyond the limits of the continental shelf, will be compared for both tanker and pipeline. In addition, these deep water disposal systems will be compared to a pipeline system for disposal 5 miles out on the continental shelf.

By providing adequate distribution and dispersion facilities, sufficient dilution may be obtained to allow this practice on a limited scale. This latter comparison will show the cost savings which may be made by disposal to the continental shelf. However, as discussed, further work is necessary in several areas before proceeding with this alternative.

SYSTEM DESCRIPTION

This section describes the facilities for the proposed ocean disposal system. The system is divided into two elements: a collection network and a bulk transportation system. A flow sheet of the proposed system utilizing an 80 mile ocean outfall is shown in Figure 25.

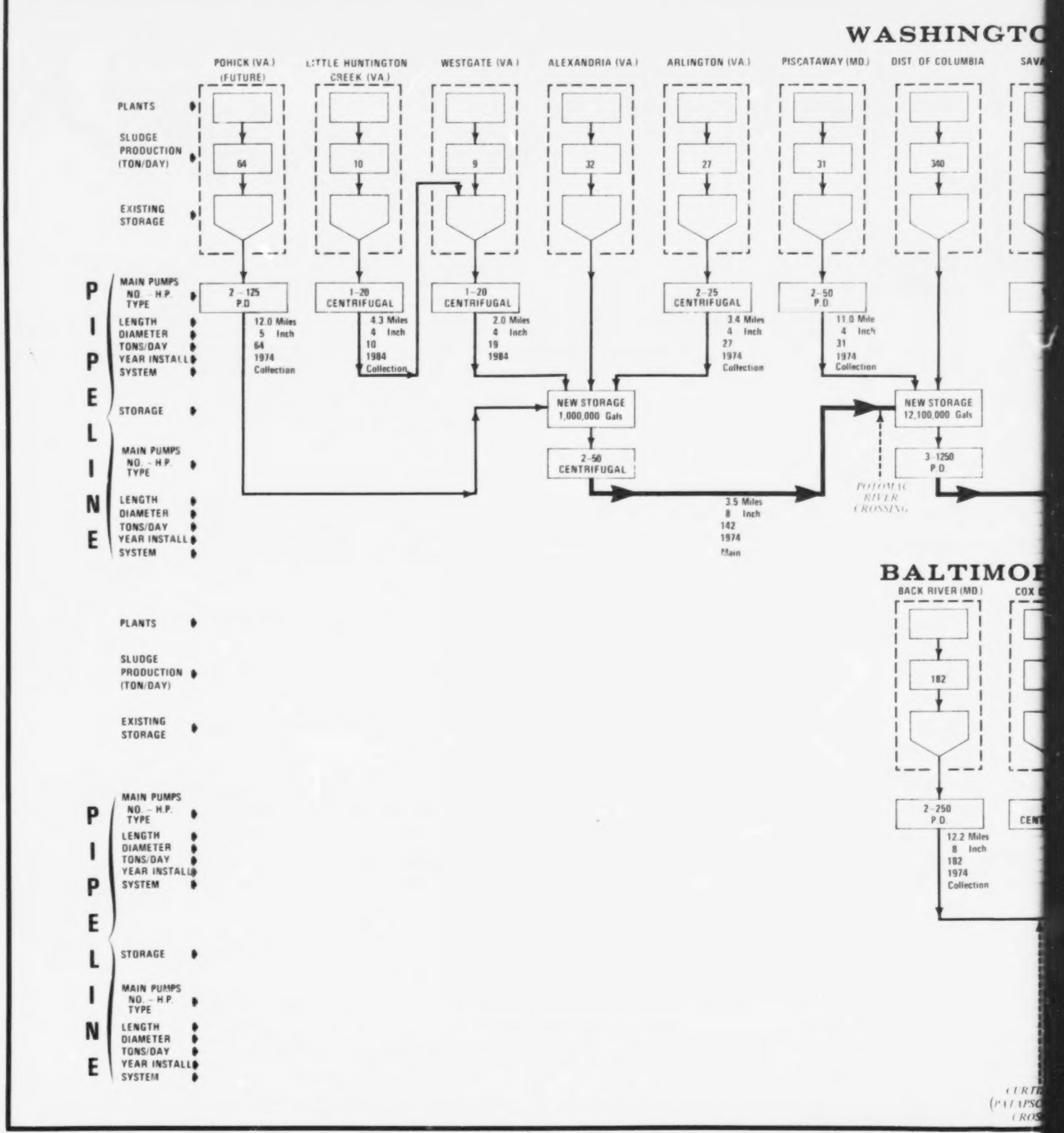
Collection System

It has been established in the study of a land disposal system for Northeast Ohio that for volumes in excess of 5 tons per day, collection of digested sludge is most economically accomplished by pipelines.

As can be seen from Figure 24, a pipeline collection system for the Baltimore-Washington area will essentially consist of two branches. One branch will take the sludge from the Baltimore region, starting at Back River and Patapsco. This collection branch will be designed to accomodate the inclusion of the Cox Creek plant in the future. The other branch will gather the sludge from the Washington, D. C. area. Initially, this branch will include the D. C. , Arlington, Alexandria, Pohick and Piscataway sewage treatment plants, but provision is made to include the Westgate, Little Huntington Creek, Parkway, Savage, Belair-Bowie and Western Branch plants as their future growth permits.

Both branches will run to a common collection point for bulk transportation located on Chesapeake Bay. The Annapolis and Broad Neck sewage treatment plants will be included by injection lines as their future growth permits. The collection system pipeline details are shown in Figure 25.

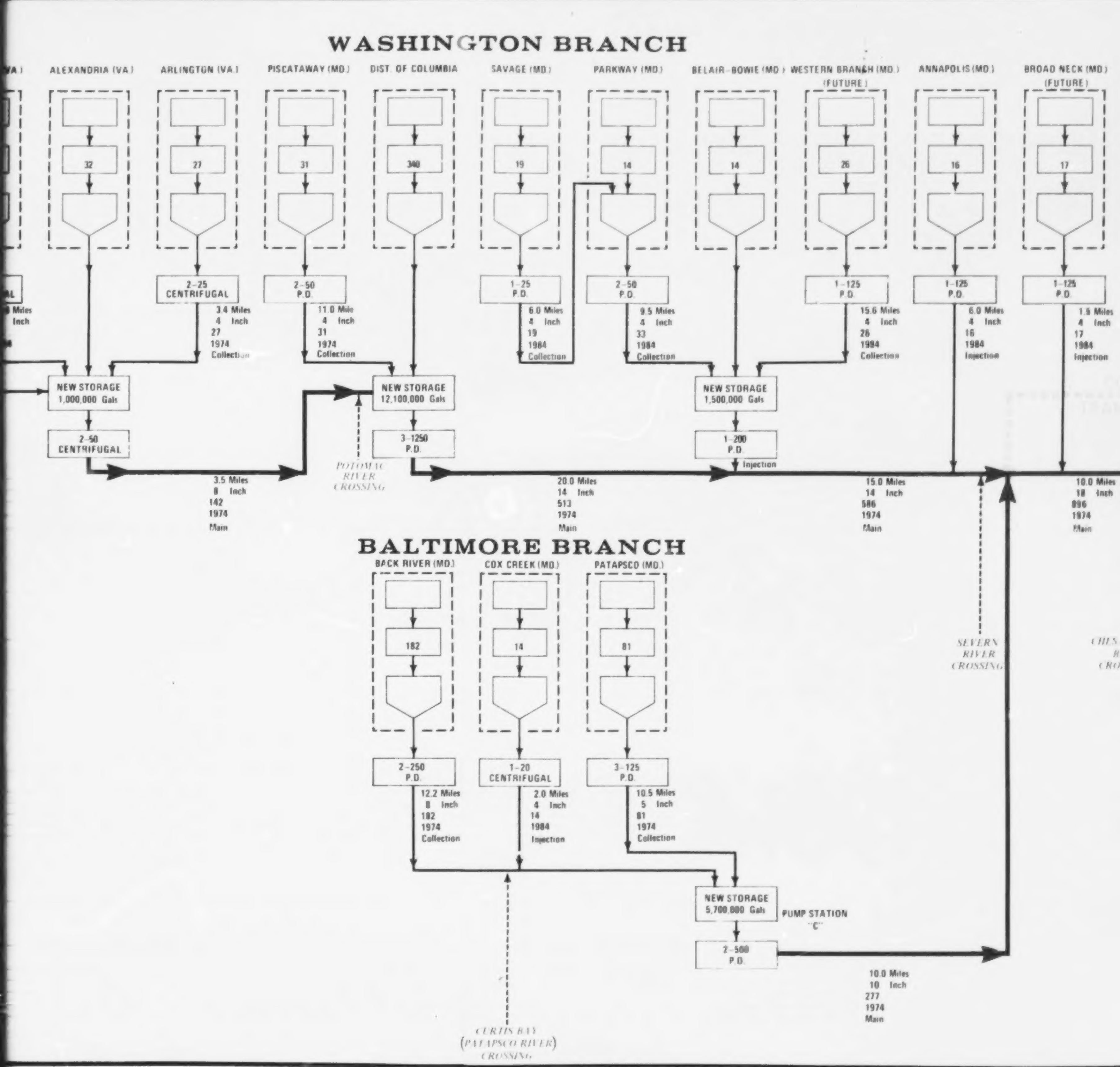
FACILITIES SUMMAR
FOR


WASHINGTO
POHICK (VA.) (FUTURE)
LITTLE HUNTINGTON CREEK (VA.)
WESTGATE (VA.)
ALEXANDRIA (VA.)
ARLINGTON (VA.)
PISCATAWAY (MD.)
DIST. OF COLUMBIA
SAV
PLANTS
SLUDGE PRODUCTION (TON/DAY)
EXISTING STORAGE
64
10
9
32
27
31
340
PIPELINE
MAIN PUMPS NO. – H.P. TYPE
LENGTH
DIAMETER
TONS/DAY
YEAR INSTALL
SYSTEM
STORAGE
2 – 125 P.D.
12.0 Miles 5 Inch 64 1974 Collection
1–20 CENTRIFUGAL
4.3 Miles 4 Inch 10 1984 Collection
1–20 CENTRIFUGAL
2.0 Miles 4 Inch 19 1984
2–25 CENTRIFUGAL
3.4 Miles 4 Inch 27 1974 Collection
2–50 P.D.
11.0 Mile 4 Inch 31 1974 Collection
NEW STORAGE 1,000,000 Gals
2–50 CENTRIFUGAL
3.5 Miles 8 Inch 142 1974 Main
NEW STORAGE 12,100,000 Gals
3–1250 P.D.
POTOMAC RIVER CROSSING
BALTIMOR
BACK RIVER (MD.)
COX
182
2–250 P.D.
12.2 Miles 8 Inch 182 1974 Collection
CENT
CURTI (PATAPSC CROS

A

F.W.P.C.A. Waste Management Study

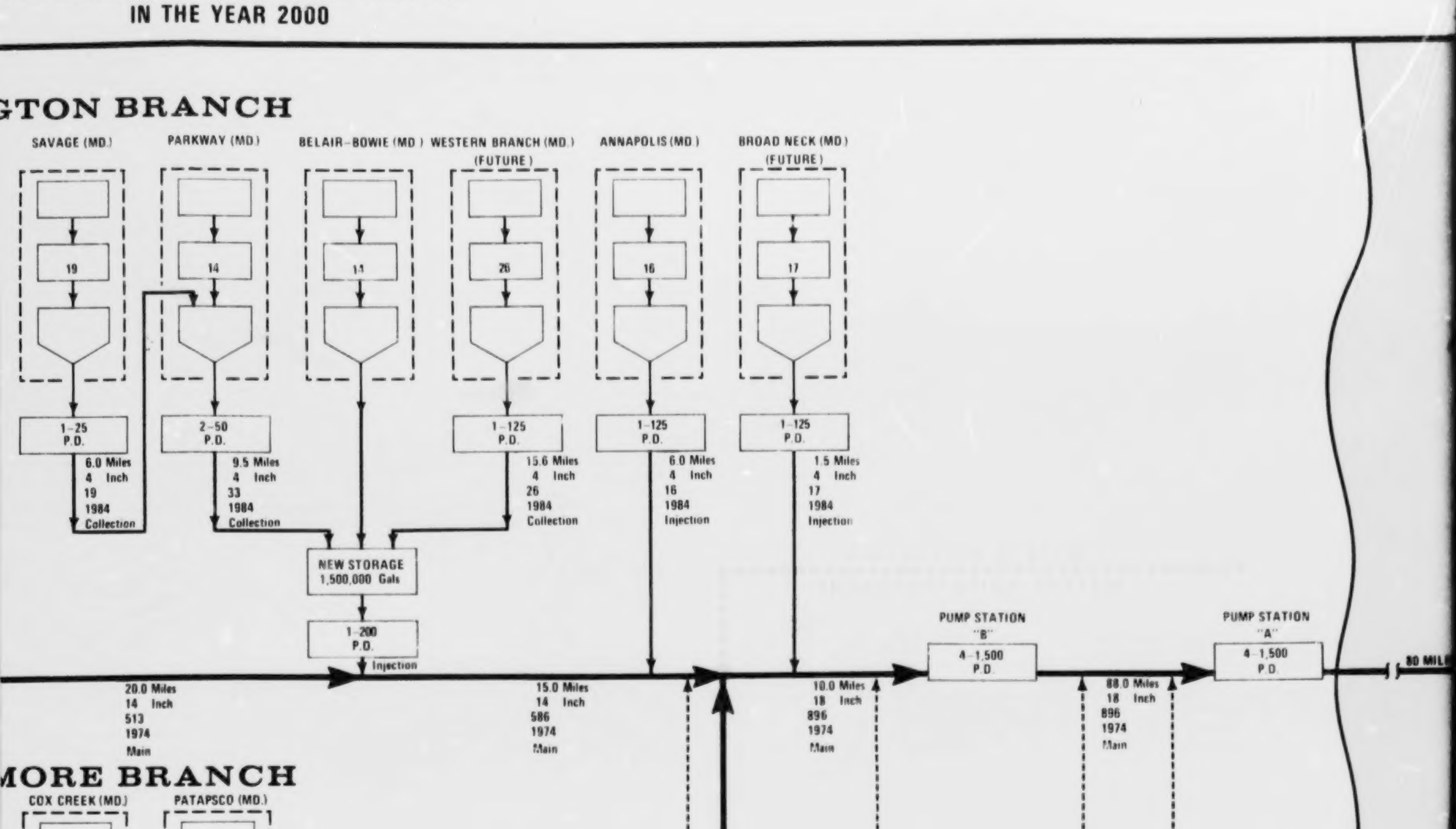
FACILITIES SUMMARY OF 80-MILE OUTFALL - OCEAN DISPOSAL SYSTEM FOR BALTIMORE - WASHINGTON D.C. AREA IN THE YEAR 2000


WASHINGTON BRANCH
ALEXANDRIA (VA.)
ARLINGTON (VA.)
PISCATAWAY (MD.)
DIST. OF COLUMBIA
SAVAGE (MD.)
PARKWAY (MD.)
BELAIR - BOWIE (MD.)
WESTERN BRANCH (MD.) (FUTURE)
ANNAPOLIS (MD.)
BROAD NECK (MD.) (FUTURE)
32
27
31
340
19
14
14
26
16
17
2-25 CENTRIFUGAL
3.4 Miles 4 Inch 27 1974 Collection
2-50 P.D.
11.0 Mile 4 Inch 31 1974 Collection
1-25 P.D.
6.0 Miles 4 Inch 19 1984 Collection
2-50 P.D.
9.5 Miles 4 Inch 33 1984 Collection
1-125 P.D.
15.6 Miles 4 Inch 26 1984 Collection
1-125 P.D.
6.0 Miles 4 Inch 16 1984 Injection
1-125 P.D.
1.5 Miles 4 Inch 17 1984 Injection
NEW STORAGE 1,000,000 Gals
2-50 CENTRIFUGAL
3.5 Miles 8 Inch 142 1974 Main
POTOMAC RIVER CROSSING
NEW STORAGE 12,100,000 Gals
3-1250 P.D.
20.0 Miles 14 Inch 513 1974 Main
NEW STORAGE 1,500,000 Gals
1-200 P.D.
Injection
15.0 Miles 14 Inch 586 1974 Main
10.0 Miles 18 Inch 896 1974 Main
SEVERN RIVER CROSSING
BALTIMORE BRANCH
BACK RIVER (MD.)
COX CREEK (MD.)
PATAPSCO (MD.)
182
14
81
2-250 P.D.
12.2 Miles 8 Inch 182 1974 Collection
1-20 CENTRIFUGAL
2.0 Miles 4 Inch 14 1984 Injection
3-125 P.D.
10.5 Miles 5 Inch 81 1974 Collection
NEW STORAGE 5,700,000 Gals
PUMP STATION "C"
2-500 P.D.
10.0 Miles 10 Inch 277 1974 Main
CURTIS BAY (PATAPSCO RIVER) CROSSING

B

F.W.P.C.A. Waste Management Study

MMARY OF 80-MILE OUTFALL - OCEAN DISPOSAL SYSTEM FOR BALTIMORE - WASHINGTON D.C. AREA IN THE YEAR 2000

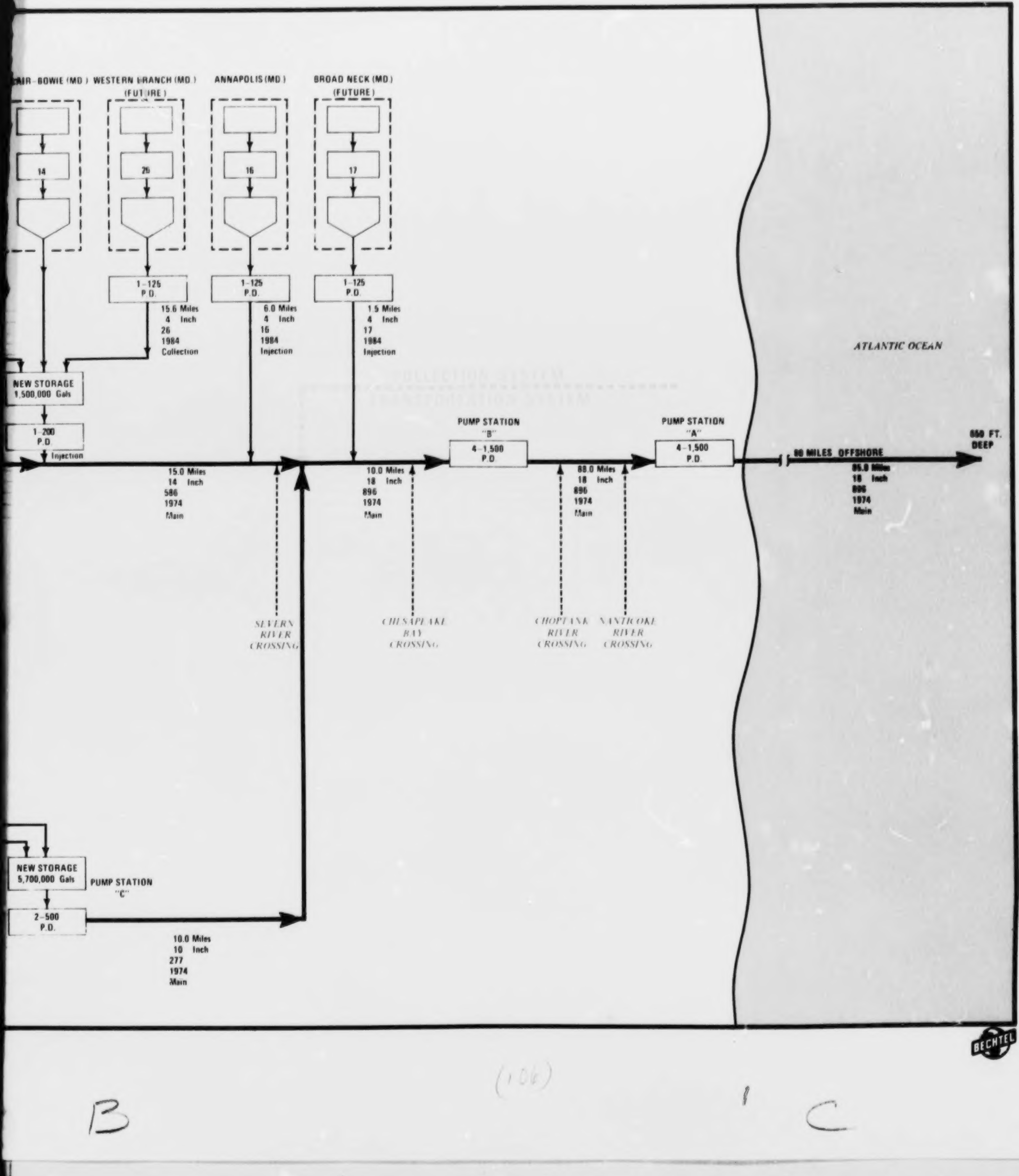

GTON BRANCH
SAVAGE (MD.)
PARKWAY (MD.)
BELAIR–BOWIE (MD.)
WESTERN BRANCH (MD.) (FUTURE)
ANNAPOLIS (MD.)
BROAD NECK (MD.) (FUTURE)
19
14
11
26
16
17
1–25 P.D.
6.0 Miles 4 Inch 19 1984 Collection
2–50 P.D.
9.5 Miles 4 Inch 33 1984 Collection
1–125 P.D.
15.6 Miles 4 Inch 26 1984 Collection
1–125 P.D.
6.0 Miles 4 Inch 16 1984 Injection
1–125 P.D.
1.5 Miles 4 Inch 17 1984 Injection
NEW STORAGE 1,500,000 Gals
1–200 P.D.
Injection
20.0 Miles 14 Inch 513 1974 Main
15.0 Miles 14 Inch 586 1974 Main
PUMP STATION "B"
4–1,500 P.D.
10.0 Miles 18 Inch 896 1974 Main
PUMP STATION "A"
4–1,500 P.D.
88.0 Miles 18 Inch 896 1974 Main
80 MIL
SEVERN RIVER CROSSING
CHESAPEAKE BAY CROSSING
CHOPTANK RIVER CROSSING
NANTICOKE RIVER CROSSING
MORE BRANCH
COX CREEK (MD.)
PATAPSCO (MD.)
14
81
1–20 CENTRIFUGAL
2.0 Miles 4 Inch 14 1984 Injection
3–125 P.D.
10.5 Miles 5 Inch 81 1974 Collection
NEW STORAGE 5,700,000 Gals
PUMP STATION "C"
2–500 P.D.
10.0 Miles 10 Inch 277 1974 Main
CURTIS BAY (PATAPSCO RIVER) CROSSING

B

t Study

OCEAN DISPOSAL SYSTEM
N D.C. AREA

Figure 25



IR-BOWIE (MD)
WESTERN BRANCH (MD) (FUTURE)
ANNAPOLIS (MD)
BROAD NECK (MD) (FUTURE)
14
26
16
17
1-125 P.D.
1-125 P.D.
1-125 P.D.
15.6 Miles 4 Inch 26 1984 Collection
6.0 Miles 4 Inch 16 1984 Injection
1.5 Miles 4 Inch 17 1984 Injection
COLLECTION SYSTEM
TRANSPORTATION SYSTEM
NEW STORAGE 1,500,000 Gals
1-200 P.D.
Injection
15.0 Miles 14 Inch 586 1974 Main
10.0 Miles 18 Inch 896 1974 Main
PUMP STATION "B"
4-1,500 P.D.
88.0 Miles 18 Inch 896 1974 Main
PUMP STATION "A"
4-1,500 P.D.
90 MILES OFFSHORE
95.0 Miles 18 Inch 896 1974 Main
650 FT. DEEP
ATLANTIC OCEAN
SEVERN RIVER CROSSING
CHESAPEAKE BAY CROSSING
CHOPTANK RIVER CROSSING
NANTICOKE RIVER CROSSING
NEW STORAGE 5,700,000 Gals
PUMP STATION "C"
2-500 P.D.
10.0 Miles 10 Inch 277 1974 Main

(106)

B

C

Transportation System

A study of the relative economics of using ocean-going tankers or pipeline to move digested sludge from the common junction point at the Broad Neck Peninsula to a safe disposal area 80 miles offshore shows that pipeline is the more economic mode of transport. Figures 26 and 27 give the bases and results of this comparison.

The tanker economics are based on the use of new T-2 tankers or equivalent (17,000 DWT), and include the cost of a wharf, loading and unloading, and storage of the sludge. The pipeline costs are based on an 18-inch pipeline. Annual capital charges in each case are based on an interest rate of 6% and a capital payback of 25 years. Also shown in Figure 26 & 27 are the costs of transporting the sludge 5 miles out on the continental shelf. This case differs from the 80-mile pipeline in that a smaller booster station is required and a diffuser system is needed to discharge the sludge into the ocean and obtain sufficient dilution.

The proposed pipeline system for the 80 mile outfall system is as shown in Figure 25. Tankage sized for three days storage at the average flow rate will be initially provided at the D. C. plant and at a pump station near Marley, which will pump the sludge from the Baltimore area. Also one day's storage will be provided at the Alexandria Plant. Additional storage will be provided at the Belair-Bowie injection station when the plants in this area are connected into the system.

The collection system will deliver sludge to the main 18-inch line. The Chesapeake Bay crossing will be achieved by attaching the pipe to the structure of the Chesapeake Bay Toll Bridge. Although at this point the pressure in the line will be low, the pipeline will be cased in order to eliminate

Figure 26
F.W.P.C.A Waste Management Study

BASIS OF ECONOMICS OF TRANSPORTATION OF DIGESTED SLUDGE FOR OCEAN DISPOSAL

Basis: 3.5 Weight % Solids

PIPELINE

80 MILE OUTFALL

DESIGN BASIS

- 18 Inch Diameter Pipe
- Pipe Velocity >3.0 ft/sec
- Route
  - 98 Miles Rural Land
  - 80 Miles Ocean Outfall

5 MILE OUTFALL

DESIGN BASIS

- 18 Inch Diameter Pipe
- Pipe Velocity >3.0 ft/sec
- Route
  - 98 Miles Rural Land
  - 5 Miles Ocean Outfall with Diffuser System

CAPITAL INVESTMENT – INCLUDING

- Pipe and Fittings
- Installation
- Pump Stations
- Right of Way
- Instrumentation and Control
- Indirects

ANNUAL CHARGES

- Capital Repayment over 25 Years
- Interest Rate at 6%
- Annual Capital Repayment at 7.82%
- Direct Operating Cost Including:
  - Power at 1¢ KWH
  - Labor at $15,000/man
  - Supplies
  - Maintenance

TANKER

80 MILES FROM SHORE

DESIGN BASIS

- T – 2 Tanker
- Tanker Capacity Per Trip
  - 17,800 Ton Liquid
  - 620 Tons Solids
- Availability 340 days/year
- 230 Miles Round Trip
  - Steaming 24 Hours
  - Loading 6 Hours
  - Unloading 6 Hours
  - Total 36 Hours
- Shore Storage 730,000 Bbls
- Dock Space for Two Tankers

CAPITAL INVESTMENT – INCLUDING

- Storage, Wharf and Loading Facilities Including Indirects at $10,900,000
- Tankers at $7,200,000 Each

ANNUAL CHARGES

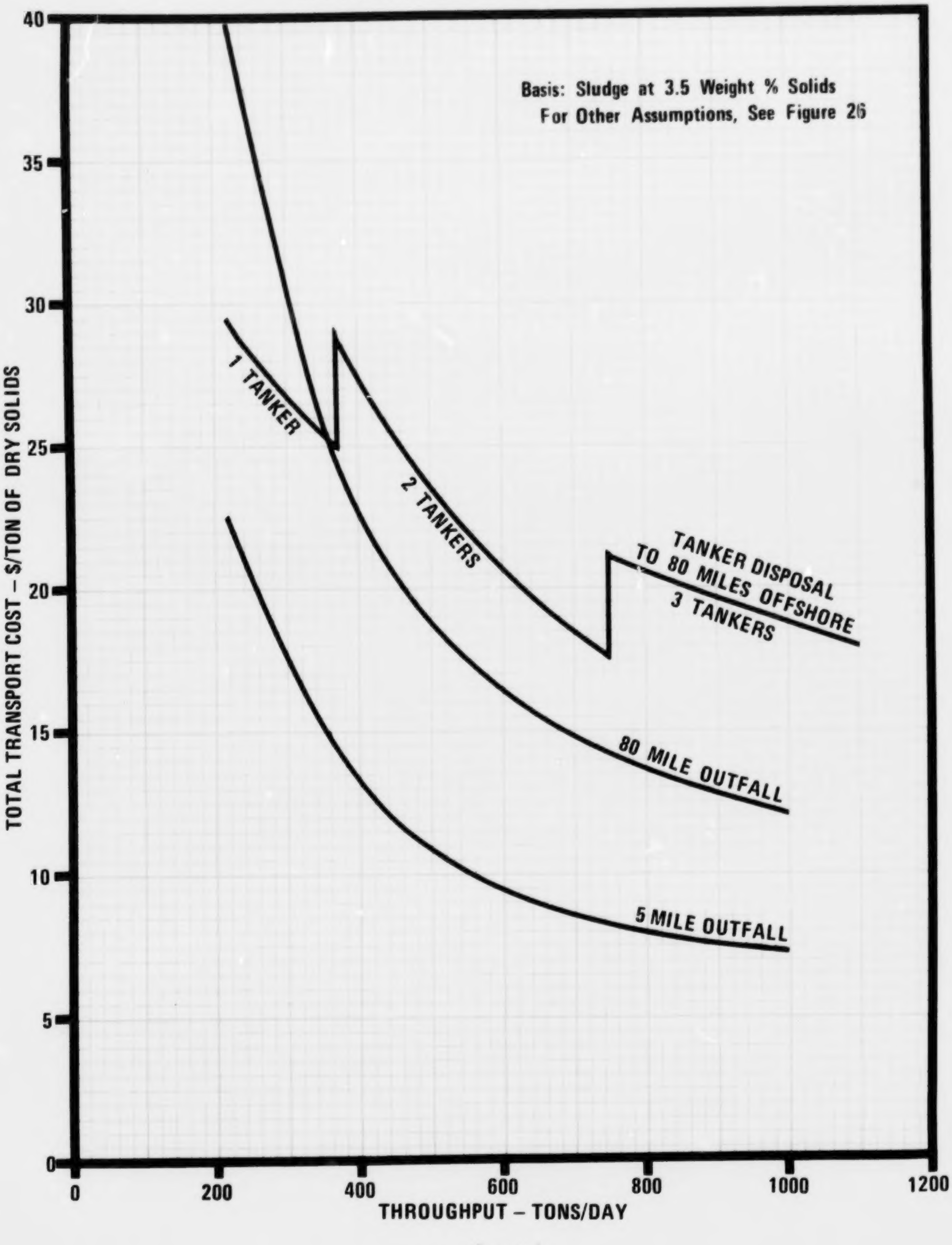
- Capital Repayment Over 25 Years
- Interest Rate at 6%
- Annual Capital Repayment at 7.82%
- Direct Operating Costs Including:
  - Fuel Oil at $2.25/Bbl
  - Power at 1¢ KWH
  - Labor at $15,000/man
  - Supplies
  - Maintenance
  - Tug Boat Service
- Staff
  - Ship 30 men/year (3 Shifts)
  - Wharf 4 Dock Hands
  - 4 Watchmen

SLUDGE TRANSPORTED (Tons of Solids/Day)	UNIT TRANSPORTATION COST ($/Ton of Solids)								
	PIPELINE						TANKER		
	80 Mile Outfall			5 Mile Outfall			80 Miles from Shore		
	Capital	Operating	Total	Capital	Operating	Total	Capital	Operating	Total
275	24.95	7.70	32.65	13.80	4.60	18.40	14.10	13.35	27.45
400	17.15	5.80	22.95	9.50	3.60	13.10	13.60	14.30	27.90
600	11.70	4.90	16.60	6.45	3.05	9.50	9.05	11.65	20.70
700	10.15	4.70	14.85	5.75	3.00	8.75	9.95	12.75	22.70
800	9.05	4.75	13.80	5.15	3.05	8.20	8.75	11.75	20.50
900	8.05	4.85	12.90	4.55	3.15	7.70	7.75	10.70	18.45

Figure 27

F.W.P.C.A. Waste Management Study

COMPARATIVE ECONOMICS OF TRANSPORTING DIGESTED SLUDGE FOR OCEAN DISPOSAL



(109)

the possibility of damage to property or people should an accident occur.

The mainline pump station located on Kent Island will employ positive displacement pumps. From Kent Island, the line will be layed overland as far as Assawoman Bay on the Atlantic Coast. A booster station located 5 miles inland from the ocean will supply the head necessary to pump the sludge 80 miles out to sea.

The pipeline industry has developed several methods for submarine pipe laying, namely, lay barge, floating string, bottom pull and reel barge. Other specialized methods are also used. Pipe laying procedures are modified as necessary to safely lay pipe in deep waters. Also, modifications are made to the basic system, as needed, to lay long runs of pipe.

Several of these pipe laying systems could be developed to provide the capability of laying pipe in six hundred feet of water. Using existing technology, pipe has been laid in waters as deep as 2500 feet in the Mediterranean. In a test with 8700 feet of pipe, line was both laid and recovered.

The length of the submarine pipeline is essentially immaterial. Pipelines of over 100 miles in length have been laid as in a single line, and networks of lines have exceeded this distance. The 80 mile outfall line will have an exterior coating of concrete to provide negative buoyancy and a protective inner lining to provide salt-water corrosion protection.

SYSTEM CAPITAL AND OPERATING COSTS

A breakdown of capital costs and annual operating costs for the three systems considered are given in Tables 20 to 25. The average disposal costs for the period 1975 to 2000 are as follows:

Disposal Cost (1971 Dollars per ton of dry solids)

	80 Mile Outfall	5 Mile Outfall	Ocean Tanker
Collection	10.74	10.74	10.74
Transportation & Disposal	16.57	9.47	28.57
Management	0.49	0.49	0.49
TOTAL	27.80	20.70	39.80

Table 20 shows the initial and future capital investment requirements for the 80 mile outfall case. The costs include direct material and installation cost for pipe, valves, pumping facilities and right-of-way. In addition to the direct costs, the system capital cost estimate includes the indirect costs of engineering, procurement, management of construction, a contingency allowance and interest during construction. All costs are based on 1969 prices, and the total cost is escalated to 1971.

The total system capital cost is $61,600,000, of which the collection system constitutes about 40% of the costs. Operating costs for each year of operation, together with the relevant capital charges are shown in Table 21. It will be noted that the initial costs are high but the increased tonnages in later years result in a rapid decrease in unit disposal costs.

TAB
F.W.P.C.A. W
80 MILE
BALTIMORE-WASHI
CAPITA

LOCATION Collection System	Initial Investment (1974) Pump Station Installed HP	 Storage (gals)	 Pipeline Length (mi)	 Dia. (in)	 (
Pohick	140	-	12	5	1
Arlington	25	-	3	4	
Alexandria	50	600,000	4	8	2
Piscataway	60	-	11	4	
District of Columbia	1,325	7,700,000	35	14	3
Back River	280	-	12	8	2
Patapsco	140	-	11	5	
Little Hunt. Creek	-	-	-	-	
Westgate	-	-	-	-	
Savage	-	-	-	-	
Parkway	-	-	-	-	
Belair-Bowie	-	-	-	-	
Annapolis	-	-	-	-	
Broad Neck	-	-	-	-	
Cox Creek	-	-	-	-	
Western Branch	-	-	-	-	
Station C	310	4,100,000	10	10	1
Right of Way					3
		Sub-Total Collection System			18
Transportation System					
Station B	3,200	-	98	18	12
Station A	3,200	-	85	18	19
Right of Way					
		Sub-Total Transport System			32
		CAPITAL INVESTMENT			50

TOTAL CAPITAL INVESTME

CAPITAL INVESTMENT ESC

1) Includes underwater crossing of Potomac River
2) Assumes bridge crossing of Severn River
3) Includes underwater crossing of Patapsco River
4) Assumes bridge crossing of Chesapeake Bay

(112)

A

LE 20
aste Management Study
OUTFALL CASE
NGTON REGIONAL SYSTEM
INVESTMENT

Capital Cost 969 Dollars)	Future Additions					
	Year Added	Pump Station		Pipeline		Capital Cost (1969 Dollars)
		Installed HP	Storage (gals)	Length (mi)	Dia. (in)	
,850,000	1993	140	-	-	-	75,000
262,000	1990	25	-	-	-	25,000
,969,000(1)	1984	50	410,000	-	-	90,000
606,000	1990	60	-	-	-	65,000
,852,000(2)	1987	1,325	4,400,000	-	-	698,000
,548,000(3)	1984	280	-	-	-	125,000
673,000	1984	140	-	-	-	249,000
	1993	125	-	-	-	75,000
-	1984	20	-	4	4	244,000
-	1984	20	-	2	4	163,000
-	1984	35	-	6	4	379,000
-	1984	60	-	10	4	578,000
	1993	60	-	-	-	65,000
-	1984	225	1,500,000	-	-	406,000
-	1984	125	-	6	4	420,000
-	1984	125	-	1.5	4	360,000
-	1984	20	-	2	4	163,000
-	1984	135	-	16	4	790,000
,843,000	1984	310	1,600,000	-	-	300,000
,807,000	1984					560,000
,410,000						5,830,000
,275,000(4)	1984	1,600	-	-	-	366,000
	1987	1,600	-	-	-	366,000
	1993	1,500	-	-	-	351,000
,125,000	1984	1,600	-	-	-	366,000
	1993	1,500	-	-	-	351,000
630,000						
,030,000						1,800,000
,440,000						7,630,000

NT (excluding escalation) = $58,070,000

ALATED TO 1971 = $61,600,000

B

TABLE 21

F.W.P.C.A. Waste Management Study

Baltimore-Washington Region

PROJECTED SLUDGE DISPOSAL COSTS USING 80 MILE OUTFALL

In Thousands of Dollars

Year	Tons/Day	Operating Costs	Capital Investment	Total Expenditure	Discount Factor(1)	Discounted Expenditure (2)
1974	-	100	50,540	50,540	1.0000	50,540
1975	278	1,315		1,315	.9434	1,241
1976	301	1,329		1,329	.8900	1,183
1977	324	1,343		1,343	.8396	1,128
1978	347	1,358		1,358	.7921	1,076
1979	371	1,374		1,374	.7473	1,027
1980	394	1,388		1,388	.7050	979
1981	442	1,455		1,455	.6651	968
1982	490	1,522		1,522	.6274	955
1983	537	1,589		1,589	.5919	941
1984	585	1,655	5,560	7,215	.5584	4,029
1985	633	1,863		1,863	.5268	981
1986	649	1,900		1,900	.4970	944
1987	665	1,936	1,065	3,001	.4688	1,407
1988	682	1,977		1,977	.4423	874
1989	698	2,009		2,009	.4173	838
1990	714	2.045	90	2,135	.3936	840
1991	732	2,091		2,091	.3714	777
1992	750	2,139		2,139	.3503	749
1993	769	2,189	915	3,104	.3305	1,026
1994	787	2,236		2,236	.3118	697
1995	805	2,283		2,283	.2942	672
1996	823	2,340		2,340	.2775	649
1997	841	2,396		2,396	.2618	627
1998	860	2,453		2,453	.2470	606
1999	878	2,510		2,510	.2330	585
2000	896	2,566		2,566	.2198	564
		49,361	58,070	107,431		

TOTAL DISCOUNTED COST (excluding escalation) $76,903,000

TOTAL DISCOUNTED COST (escalated to 1971(3)) $81,500,000

(1) Discounted @ 6% rate.
(2) Base year is 1974 with costs in 1969 Dollars.
(3) Escalated at 3% per year.

Tables 22 and 23 show the capital costs, and the annual direct operating costs for the 5-mile outfall system. The capital investment of $45,900,000 is less than that for the 80-mile system, as are the operating costs. The total discounted expenditure over the period 1974 to 2000 is $60.8 million compared with $81.5 million for the 80-mile system.

As shown previously, these reduced costs result in a decrease in average disposal cost of $7.10 per ton of solids over the 80-mile system. Although this system is considerably cheaper than the 80-mile outfall system, the savings in money must be weighed against the risk involved in terms of possible damage to the marine environment by large scale disposal of wastes to the continental shelf. The additional cost for the 80-mile system amounts to some 20 cents per year for every person in the region. Piping the sludge to the continental shelf should be chosen in the absence of any supporting data that could verify the safety of the closer dump site.

The cost estimates for the Ocean tanker case are given in Tables 24 and 25. The costs are based on the hauling of sludge at a concentration of 3.5 weight percent to a distance of 80 miles from the coast. The capital cost ($60.1 million) is comparable to that of the 80-mile outfall system, but the higher operating costs associated with the tanker operation result in a total discounted expenditure of $94.5 million and correspondingly higher unit disposal costs.

It is possible that, by employing used tankers which have been modified for sludge service, the disposal costs for the tanker case could be reduced. However, it was beyond the scope of this study to preduct the availability and cost of used tankers in 1975, and the above costs are

F.W.P.C

5-

BALTIMORE-

C

LOCATION	Initial Investment (1974)			
	Pump Station		Pipeline	
	Installed HP	Storage (gals)	Length (mi)	Dia. (i
Collection System (see Table 20)				
Sub-Total Collection System				
Transportation System				
Station B	3,200	-	98	18
Station A Right-of-Way	1,400	-	20	18
Sub-Total Transportation System				
CAPITAL INVESTMENT				
TOTAL CAPITAL INVESTM				
CAPITAL INVESTMENT ES				

(1) See relevant notes in Table
(2) Assumes bridge crossing of Chesapeake Bay.
(3) Includes diffuser system.

A

BLE 22
/aste Management Study
OUTFALL CASE
NGTON REGIONAL SYSTEM
L INVESTMENT

	Future Additions					
Capital Cost 969 Dollars)	Year Added	Pump Station Installed HP	Pump Station Storage (gals)	Pipeline Length (mi)	Pipeline Dia (in)	Capital Cost (1969 Dollars)
18,410,000(1)	1984					4,827,000
	1987					698,000
	1990					90,000
	1993					215,000
18,410,000						5,830,000
12,275,000(2)	1984	1600	-	-	-	366,000
	1987	1600	-	-	-	366,000
	1993	1500	-	-	-	351,000
4,815,000(3)	1990	700	-	-	-	297,000
630,000						
17,720,000						1,380,000
36,130,000						7,210,000

excluding escalation) = $43,340,000

TED TO 1971 = $45,900,000

B

TABLE 23

F. W. P. C. A. Waste Management Study

Baltimore-Washington Region

PROJECTED SLUDGE DISPOSAL COSTS USING 5 MILE OUTFALL & DIFFUSER

In Thousands of Dollars

Year	Tons/Day	Operating Costs	Capital Investment	Total Expenditure	Discount Factor (1)	Discounted Expenditure (2)
1974	-	100	36, 130	36, 230	1.0000	36, 230
1975	278	1, 005		1, 005	.9434	948
1976	301	1, 017		1, 017	.8900	905
1977	324	1, 029		1, 029	.8396	864
1978	347	1, 042		1, 042	.7921	825
1979	371	1, 055		1, 055	.7473	788
1980	394	1, 067		1, 067	.7050	752
1981	442	1, 119		1, 119	.6651	744
1982	490	1, 172		1, 172	.6274	735
1983	537	1, 224		1.224	.5919	725
1984	585	1.276	5, 193	6, 469	.5584	3, 612
1985	633	1, 468		1, 468	.5268	773
1986	649	1, 498		1, 498	.4970	745
1987	665	1, 526	1, 064	2, 590	.4688	1, 214
1988	682	1, 555		1, 555	.4423	688
1989	698	1, 583		1, 583	.4173	661
1990	714	1, 612	387	1, 999	.3936	787
1991	732	1, 646		1, 646	.3714	611
1992	750	1, 680		1, 680	.3503	589
1993	769	1, 718	566	2, 284	.3305	755
1994	787	1, 753		1, 753	.3118	547
1995	805	1, 788		1, 788	.2942	526
1996	823	1, 829		1, 829	.2775	508
1997	841	1, 872		1, 872	.2618	490
1998	860	1, 914		1, 914	.2470	473
1999	878	1, 956		1, 956	.2330	456
2000	896	1, 999		1, 999	.2198	439
		38, 503	43, 340	81, 843		

TOTAL DISCOUNTED COST (excluding escalation)	$57, 390, 000
TOTAL DISCOUNTED COST (escalated to 1971(3))	$60, 800, 000

(1) Discounted @ 6% rate.
(2) Base year is 1974 with costs in 1969 dollars.
(3) Escalated at 3% per year.

TABLE 24

F. W. P. C. A. Waste Management Study

Baltimore - Washington Region

OCEAN TANKER CASE

CAPITAL INVESTMENT

Location	Initial Investment (1974)		Future Additions		
	Item	Capital Cost (1969 Dollars)	Year Added	Item	Capital Cost (1969 Dollars)
Collection System		18,410,000	1984		4,827,000
(See Table 20)			1987		698,000
			1990		90,000
			1993		215,000
Sub-Total Collection System		18,410,000			5,830,000
Tanker Terminal					
	Pumps (1000 Hp) Storage (730,000 bbls) Wharf	7,130,000			
	Land	3,810,000			
Sub-Total Tanker Terminal		10,940,000			
Tankers					
	One T-2	7,200,000	1980	One T-2	7,200,000
			1990	One T-2	7,200,000
Sub-Total Tankers		7,200,000			14,400,000
Capital Investment		36,550,000			20,230,000

TOTAL CAPITAL INVESTMENT
(excluding escalation) = $56,780,000

TOTAL CAPITAL INVESTMENT
(escalated to 1971) = $60,100,000

TABLE 25

F.W.P.C.A. Waste Management Study

Baltimore-Washington Region

PROJECTED SLUDGE DISPOSAL COSTS USING OCEAN TANKERS

In Thousands of Dollars

Year	Tons/Day	Operating Costs	Capital Investment	Total Expenditure	Discount Factor (1)	Discounted Expenditure (2)
1974	-	100	36,550	36,650	1.0000	36,550
1975	278	1,928		1,928	.9434	1,819
1976	301	2,079		2,079	.8900	1,850
1977	324	2,231		2,231	.8396	1,873
1978	347	2,482		2,482	.7921	1,966
1979	371	2,534		2,534	.7473	1,893
1980	394	2,686	7,200	9,880	.7050	6,970
1981	442	2,803		2,803	.6651	1,864
1982	490	2,918		2,918	.6274	1,830
1983	537	3,035		3,035	.5919	1,796
1984	585	3,152	4,827	7,979	.5584	4,455
1985	633	3,407		3,407	.5268	1,801
1986	649	3,558		3,558	.4970	1,768
1987	665	3,709	698	4,407	.4688	2,066
1988	682	3,860		3,860	.4423	1,707
1989	698	4,009		4,009	.4173	1,672
1990	714	4,160	7,290	11,450	.3936	4,507
1991	732	4,203		4,203	.3714	1,561
1992	750	4,246		4,246	.3503	1,487
1993	769	4,292	215	4,507	.3305	1,490
1994	787	4,337		4,337	.3118	1,352
1995	805	4,382		4,382	.2942	1,289
1996	823	4,412		4,412	.2775	1,224
1997	841	4,445		4,445	.2618	1,164
1998	860	4,476		4,476	.2470	1,105
1999	878	4,508		4,508	.2330	1,050
2000	896	4,540		4,540	.2198	998
		92,492	56,780	149,272		

TOTAL DISCOUNTED COST (excluding escalation)	$89,107,000
TOTAL DISCOUNTED COST (escalated to 1971(3))	$94,450,000

(1) Discounted @ 6% rate.
(2) Base year is 1974 with costs in 1969 Dollars.
(3) Escalated at 3% per year.

based on the use of new tankers. Also, the transportation of a more concentrated sludge, of, say 7 percent solids would result in reduced tanker costs. Assuming full utilization, operating costs for tankers would roughly decrease proportionately to the percent solids concentration. However, since neither the technology nor the cost data are presently available for a thickening process which would result in negligible nutrient discharge or solids loss, an accurate economic analysis of this case is not possible without further work.

ECONOMIC AND ENVIRONMENTAL IMPLICATIONS OF THE OCEAN DISPOSAL SYSTEM

The consideration of a regional ocean disposal system for digested sludge in the Baltimore-Washington region comes at an opportune time. Currently, both cities dispose of sludge by dewatering and stockpiling. The dewatered sludge is then made available for use as a soil conditioner.

However, the dried sludge market has not developed to the potential that earlier indications had predicted. For example, the Baltimore Back River plant disposed of over 30 percent of the total sludge produced during the 14 years to 1967, and of only 6.1 percent of the 1967 production(9). With this diminishing demand for dried sludge, the balance of the processed sludge has to be stored on the plant site. Obviously this is an unsatisfactory situation.

Another major source of concern with current disposal methods in this region is that of nutrient discharge to the local waterways such as the Potomac River and Chesapeake Bay. The D.C. plant now discharges elutriate directly to the plant outfall while at Back River, it is recycled back to the head end of the plant and thus is eventually discharged with the plant effluent.

The proposed deep-ocean disposal system eliminates both of these problems. The pipeline system, by taking the total digester output (i.e. sludge and supernatant) removes the problem of disposal of nutrient-rich waters, in addition to disposing of 100 percent of the sludge solids remaining from digestion.

The pipeline system is also more economic than other methods proposed (9) (10) for this region, and, since the major portion of its costs are as fixed capital,it is less sensitive to inflationary effects. Unit process cost studies are not available for the existing sludge disposal processes used in the Baltimore-Washington region. However, in projecting future costs to compare with those given in the previous section for the pipeline system,it may be safely assumed that the most practical alternate is that of sludge incineration. This method has been proposed for the D. C. Water Pollution Control Plant.(10) The range of costs for sludge incineration has been extensively documented (e.g. Burd(4)). For comparison purposes a cost of $40 per ton of solids is used for incineration costs. This figure is low, and probably could not be realized commercially. A detailed study of the D.C. plant(10) indicates that with the exception of ocean disposal, multiple hearth incineration is the cheapest method of sludge disposal, but would cost from $52 to $58 per ton. However, the $40 per ton figure will serve as a good comparison with the pipeline costs in evaluating the economic benefit of the ocean disposal system.

Table 26 shows the 1974 discounted costs for sludge incineration during the period 1975-2000, for tonnages ranging from 278 to 896 per day, is of the order of $103 million. This compares with $81.5 million for the 80 mile outfall system ($27.80 per ton average cost over the 26 year period).

Hence, the economics of the pipeline system are favorable even when compared with an optimistic estimate of incineration costs.

TABLE 26

F.W.P.C.A. Waste Management Study

PROJECTED SLUDGE DISPOSAL COSTS
BALTIMORE - WASHINGTON REGION
FILTRATION - INCINERATION

In Thousands of Dollars

Year	Dry Tons/Day	Dry Tons/Yr.	Total Cost @ $40/ton	Discount Factor(1)	Discounted Expenditure (1971 Dollars)
1974	-	-	-	-	-
1975	278	101,500	4060	.9434	3830
1976	301	109,900	4400	.8900	3916
1977	324	118,300	4730	.8396	3971
1978	347	126,700	5070	.7921	4016
1979	371	135,400	5420	.7473	4050
1980	394	143,800	5750	.7050	4054
1981	442	161,300	6450	.6651	4290
1982	490	178,900	7160	.6274	4492
1983	537	196,000	7840	.5919	4641
1984	585	213,500	8540	.5584	4769
1985	633	231,000	9240	.5268	4868
1986	649	236,900	9480	.4970	4712
1987	665	242,700	9710	.4688	4552
1988	682	248,900	9960	.4423	4405
1989	698	254,800	10,190	.4173	4252
1990	714	260,600	10,420	.3936	4101
1991	732	267,200	10,690	.3714	3970
1992	750	273,800	10,950	.3503	3836
1993	769	280,700	11,230	.3305	3712
1994	787	287,300	11,490	.3118	3583
1995	805	293,800	11,750	.2942	3457
1996	823	300,400	12,020	.2775	3336
1997	841	307,000	12,280	.2618	3215
1998	860	313,900	12,560	.2470	3102
1999	878	320,500	12,820	.2330	2987
2000	896	327,000	13,080	.2198	2875
		5,931,800	TOTAL COST =		$ 102,992,000
			SAY		$ 103,000,000

(1) Discounted @ 6% rate

RECOMMENDED DEVELOPMENT PROGRAM

As mentioned previously, the long-term effects on the marine environment of disposal of wastes to the ocean have not as yet been fully evaluated. With disposal of wastes to the shallow waters of the continental shelf, it is possible that due to the limited amount of dilution water, a severe pollution problem could result from widespread adoption of this practice. In the case of deep ocean disposal, it is anticipated that the availability of nearly unlimited dilution water and the lack of commercial fishing will allow implementation of this program with little chance of mishap. However, periodic monitoring of the deep water disposal area should be included to ensure that a pollution problem does not eventually develop.

From Tables 21 and 23, it is seen that a 5-mile outfall for the Baltimore-Washington region would result in savings of some $20.7 million over the deep water system. If shelf disposal was adopted for other ocean disposal systems, additional savings would accrue. The total potential aggregate savings from close in disposal justifies a major research and development program to establish the environmental and engineering criteria required for realizing these savings.

It is beyond the scope of this study to estimate the cost of the development work required. However, due to the nature and magnitude of such a program, it is certain that the costs will be large. Nevertheless, at this point, the program is essential, and as indicated above, is economically justifiable. Among the aspects that should be investigated are:

Studies should be made immediately of existing outfalls and disposal areas of a variety of magnitudes in several distinct marine biogeographic locations. These studies should examine the flora and fauna in the immediate vicinity of discharge, the temporal and spatial dimensions of sludge fields, rates of bio-degradation and utilization of sludge by marine organisms, and the dissolved inorganic and organic substances resulting from coastal discharges.

- The public health significance of coastal discharges should be investigated.

- Research should be expanded and intensified on the bioconcentration of waste components by marine organisms, particularly, with respect to heavy metals.

- More work is needed on the design of diffusers to ensure rapid and adequate dilution of sludge. The analysis of initial mixing over an outfall has associated with it many complicated problems which are not as yet adequately solved. Also, the transitional stage between initial jet mixing and natural oceanic diffusion requires intensive study.

- Means for nutrient and heavy metal removal from sludge should be investigated.

INSTITUTIONAL MANAGEMENT CONSIDERATIONS

The need for a regional approach to the waste disposal problem was discussed in some detail in the institutional management portion of the Northeast Ohio land disposal section and will not be repeated here. It should be noted, however, that whereas a great deal of imaginative thinking and a high degree of cooperation on the part of all involved public authorities and private interests was necessary in the Northeast Ohio system, it is even more critical in the Baltimore-Washington Ocean disposal system. In fact, the whole matter of institutional management is probably the biggest problem which must be overcome before the proposed ocean disposal system could become a reality. This is a result of the fact that the system directly involves:

- Sixteen Municipalities
- The State of Virginia
- The State of Maryland
- The District of Columbia
- The Federal Government

In addition, the system discharges into international waters. This is much more complex than the proposed land disposal system, which was entirely within the State of Ohio. Although there are a number of regional organizations, such as the Metropolitan Washington Council of Governments and the Baltimore Regional Planning Council, designed to promote coordinated cooperative action among the independent jurisdictions, there is not now an existing body which could handle the proposed disposal system such as the

O. W. D. A. in Ohio. A new jurisdictional body would have to be formed. However, since the waste disposal problem is very serious and the regional approach offers an effective solution as well as substantial economic benefits to each government, the required high degree of cooperation for establishing this new body is justified.

In light of these institutional problems, it is felt that a private enterprise alternate, at this stage, would not be practical and that a regional public body is the only feasible alternative. Such a body could be modeled after the Delaware River Basin Compact which was formed by the States of Delaware, New Jersey, New York and Pennsylvania and the United States of America, to manage the water resources of the Delaware River Basin. Numerous similar jurisdictional bodies exist such as the St. Lawrence Seaway Authority, and the New York Port Authority. It is a recommendation of this study that such a new jurisdictional body be formed by the respective states and the District of Columbia under the auspices of the Federal Government. The body should have broad jurisdictional powers, including the ability to own and operate facilities, issue bonds, accept grants from the Federal Government and exert the rights of eminent domain.

The first job of this body would be to investigate, in depth, the effects of dumping the proposed quantities of digested sludge into the ocean. Currently, there is no law or international treaty to control dumping of wastes in international waters. Because of its implications, many federal agencies would probably be interested in participating.

The second task of the proposed body would be to demonstrate the ocean disposal concept utilizing the results of the investigation. This might entail an interim, two year sludge disposal program to specific sites from one or more plants in which detailed monitoring would be conducted. Following the successful demonstration of the concept, of course, a full scale regional system could be implemented.

A detailed formulation of the structure of the proposed jurisdictional body is beyond the scope of this study, since it must be done in cooperation with high level officials from the respective governments. This should probably be done by a commission charged with the task of formulating a new jurisdictional structure subject to ratification by the involved governments. Since two states, sixteen municipalities, the District of Columbia, and territorial waters are involved, plus federal laws concerning construction and research grants, it is recommended that the commission be formed by either congressional statute, such as those enacted for the formation of various basin commissions or that an autonomous commission be formed, similar to the Washington Metropolitan Transit Authority, with the capability of obtaining revenue for capital and operating expenses from the respective participants.

The main message intended to be conveyed by this section is that the institutional management problems of ocean disposal in the Baltimore-Washington region are difficult and complex, but the economies that can be realized justify the expenditure of enormous energies to develop the type of inter-regional organization necessary to carry-out the regional plan.

If it becomes impossible to obtain agreement with all governments, it would still be possible to formulate a smaller scale system to serve either the Baltimore or Washington region alone. Although a definitive cost analysis of these alternatives was not made, it would probably result in increasing the average unit costs of disposal on the order of five dollars per ton. Hence, a substantial economic incentive would still remain.

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APPENDIX B

PROJECTION OF FUTURE SLUDGE QUANTITIES

NORTHEAST OHIO REGION

For projecting sludge quantities in this region, it is assumed that the following programs are carried forth:

1. The upgrading of all major wastewater treatment plants to meet acceptable secondary treatment standards by 1975. This is taken as 90% removal of suspended solids. By the year 2000, further upgrading is assumed to result in the removal of practically all suspended solids.
2. The phasing out of all small sewage treatment plants and the direct connection of the municipalities to the large metropolitan plants by regional interceptors. This plan was recommended in the F. W. P. C. A. "Lake Erie Report" of March 1 1968.(2) It is assumed to take place between the years 1980 through 1990.
3. Implementation of an advanced wastewater treatment program for phosphorous removal. Although the treatment method and timetable for this step can not be firmly established at this time, it appears likely that chemical coagulation will be used. For this study, it is assumed that the program will begin in 1980 and be completely operating by the year 1985. It is recognized that stringent water quality control measures may be undertaken, resulting in an earlier beginning. Full implementation is assumed to result in the production of 50 ppm of waste chemical sludge measured on the total sewage flow to the plant. This is equivalent to 0.21 tons of sludge per MGD and results in increasing sludge quantities for the year 2000 by approximately one third over the case of digested sludge alone.

Based on the above, projected sludge quantities are shown in Table B-1 for each plant in the years 1968, 1975, and the year 2000. The projection method used is based upon the procedure outlined in Section 3 of Volume II. Raw sludge is first determined as the product of the population served, suspended solids contribution, and the overall removal of suspended solids in the total treatment process. Digested sludge is taken as the product of raw sludge times a digestion loss factor to account for the conversion of some of the organic matter to gas and water. Chemical sludge is computed as

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SLUDGE QUANTITIES PROJECT

Plant	Year	Area Served	Population Served	Sewage Flow (MGD)	Per Capita Suspended Solids Contribution (lbs/cap/day)	Suspended Solid Plant Load (dry tons/day)
Cleveland Easterly	1968	Tributary	561,000	126	0.29	81.2
	1975	"	573,000	135	0.38	108.9
	2000	"	608,000	158	0.42	127.7
Cleveland Southerly	1968	Tributary	565,000	67	0.19	54.0
	1975	"	622,000	81	0.24	74.6
	2000	"	783,000	118	0.28	109.6
		Metro Add'n	320,000	47	0.28	44.8
			1,103,000	165		154.4
Cleveland Westerly	1968	Tributary	161,000	33	0.33	26.4
	1975	"	158,000	35	0.37	29.3
	2000	"	146,000	42	0.47	34.3
Canton	1968	Tributary	162,000	19	0.29	23.5
	1975	"	189,000	24	0.30	28.4
	2000	"	284,000	40	0.32	45.5
Lakewood	1968	Tributary	90,000	15	0.20	8.9
	1975	"	92,000	16	0.22	10.1
	2000	"	100,000	19	0.25	12.5
		Metro Add'n	590,000	109	0.25	73.8
			690,000	128		86.3
Akron	1968	Tributary	420,000	73	0.47	101.9
	1975	"	480,000	88	0.50	120.0
	2000	"	650,000	114	0.54	175.5
		Metro Add'n	390,000	68	0.29	56.6
			1,040,000	182		232.1

(1) Raw sludge pumped to Southerly plant for digestion

(2) Waste chemical sludge included in total for Southerly plant

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/aste Management Study

ON: NORTHEAST OHIO REGION

Suspended Solids Removal (%)	Raw Sludge (dry tons/day	Digestion Loss (%)	Digested Sludge (dry tons/day)	Waste Chem. Sludge	Total Digested + Waste Chem. Sludge
84	68.1	(1)	-	-	-
90	98.0	(1)	-	-	-
100	127.7	(1)	-	32.9	(2)
82	44.3	25	84.3	-	84.3
90	67.1	30	115.6	-	115.6
100	109.6	30	168.2	57.5	225.7
100	154.4	30	197.5	67.3	264.8
45	14.5	36	9.3	-	9.3
90	26.4	40	15.8	-	15.8
100	34.3	40	20.6	8.7	29.3
88	20.7	35	13.5	-	13.5
90	25.6	40	15.4	-	15.4
100	45.5	40	27.3	8.3	35.6
75	6.7	40	4.0	-	4.0
90	9.1	40	5.5	-	5.5
100	12.5	40	7.5	3.9	11.4
100	86.3	40	51.8	26.7	78.5
72	73.4	25	55.1	-	55.1
90	108.0	40	64.8	-	64.8
100	175.5	40	105.3	23.7	129.0
100	232.1	40	139.3	37.9	177.2

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50 ppm on the projected sewage flow.

The sewage flow and suspended solids removal in 1968 were obtained from plant operating records. Per capita suspended solids contributions were generally calculated from records of sewage flow and suspended solids concentration. Populations served were usually based on prior detailed engineering studies. In some cases, questionnaires were sent to plant superintendents or other local officials through the cooperation of the Ohio Dept. of Health, to obtain the necessary information. Metro additions were assumed to have the same wastewater parameters as the major plant, except for Akron, where the industrial contribution is very high. In this case, the average per capita values outlined in Volume II were used instead.

An important point should be understood about the 1968 quantities, namely that the calculations are theoretical. Firstly, this procedure assumes that raw sludge production is equivalent to suspended solids removal. After allowance for recycle effects, examination of the records for the two largest plants, Easterly and Southerly, indicate that this relationship is approximately true. Secondly, the digested sludge production refers to total digester output, i.e., it assumes that there is no supernatant produced. At present, supernatant is separated at all plants and either recycled or separately disposed of.

Akron presents a special case. It is currently digesting only excess waste activated sludge, and the high amount of industrial waste has led to frequent digester upsets. Primary sludge is directly filtered and incinerated. However, in 1970 Akron is scheduled to begin disposing of waste activated sludge by wet oxidation. The digesters are scheduled to be shut down and only primary sludge will continue to be filtered and incinerated. However, for uniformity in presentation, the quantities shown for all three years assume that both primary and waste activated sludge are digested.

BALTIMORE-WASHINGTON REGION

Sludge quantities in this region were projected by a method similar to that described previously for the Northeast Ohio region. It was assumed that the following programs were carried forth:

1. The upgrading of all major wastewater treatments plants so as to result in 90% removal of suspended solids in 1975 and removal of practically all suspended solids by the year 2000.

2. Implementation of a program of chemical coagulation for phosphorous removal, beginning in 1980 and completely operating by the year 1985. It is assumed that 50 ppm of waste chemical sludge is produced on the total sewage flow to the plant.

Projected sludge quantities are shown in Table B-2 for each plant in the years 1968, 1975 and the year 2000. The procedure used closely follows that previously described for Northeast Ohio. Most of the data was obtained from prior engineering studies.

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F. W. P. C. A.

SLUDGE QUANTITIES PROJECT

Plant	Year	Population Served	Sewage Flow (MGD)	Per Capita Suspended Solids Contribution (lbs/cap/day)	Suspended Solids Plant Load (dry tons/day)
Dist. of Col.	1968	1,700,000	232	0.22	189
	1975	2,070,000	288	0.24	248
	2000	3,122,000	419	0.27	422
Arlington	1968	200,000	18.0	0.26	26.0
	1975	210,000	21.0	0.27	28.4
	2000	245,000	28.2	0.29	35.6
Alexandria	1968	120,000	14.0	0.26	15.6
	1975	158,000	19.1	0.27	21.4
	2000	279,000	35.0	0.29	40.5
Westgate	1968	80,000	9.6	0.26	10.4
	1975	80,000	9.8	0.27	10.8
	2000	80,000	11.2	0.29	11.6
Pohick	1968	-	-	-	-
	1975	152,000	19.0	0.27	20.5
	2000	552,000	77.2	0.29	80.0
Little Hunt. Creek	1968	26,500	2.2	0.26	3.5
	1975	38,500	4.8	0.27	5.2
	2000	82,000	11.5	0.29	11.9
Piscataway	1968	34,200	4.1	0.26	4.5
	1975	110,000	13.8	0.27	14.9
	2000	264,000	37.0	0.29	38.4
Parkway	1968	22,500	2.7	0.26	2.9
	1975	44,000	5.5	0.27	5.9
	2000	120,000	16.8	0.29	17.4

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Management Study

BALTIMORE-WASHINGTON REGION

uspended ds Removal (%)	Raw Sludge (dry tons/day	Digestion Loss (%)	Digested Sludge (dry tons/day	Waste Chem. Sludge (dry tons/day)	Total Digested + Waste Chem. Sludge (dry tons/day)
72	136	40	81.6	-	81.6
90	223	40	134	-	134
100	422	40	253	87	340
65	16.9	40	10.1	-	10.1
90	25.5	40	15.3	-	15.3
100	35.6	40	21.4	5.9	27.3
80	12.5	40	7.5	-	7.5
90	19.3	40	11.6	-	11.6
100	40.5	40	24.3	7.3	31.6
60	6.2	40	3.7	-	3.7
90	9.7	40	5.8	-	5.8
100	11.6	40	7.0	2.3	9.3
-	-	-	-	-	-
90	18.5	40	11.1	-	11.1
100	80.0	40	48.0	16.1	64.1
80	2.8	40	1.7	-	1.7
90	4.7	40	2.8	-	2.8
100	11.9	40	7.1	2.4	9.5
80	3.6	40	2.1	-	2.1
90	13.4	40	8.0	-	8.0
100	38.4	40	23.0	7.7	30.7
70	2.0	40	1.2	-	1.2
90	5.4	40	3.2	-	3.2
100	17.4	40	10.5	3.5	14.0

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TABLE B-2
F. W. P. C. A. Waste Management Study
SLUDGE QUANTITIES PROJECTION:
BALTIMORE-WASHINGTON REGION
PAGE 2

Plant	Year	Population Served	Sewage Flow (MGD)	Per Capita Suspended Solids Contribution (lbs/cap/day)	Suspended Solids Plant Load (dry tons/day)
Belair-Bowie	1968	33,000	1.8	0.26	4.3
	1975	56,500	7.1	0.27	7.1
	2000	122,000	17.1	0.29	17.7
Western Branch	1968	-	-	-	-
	1975	120,000	15.0	0.27	16.2
	2000	225,000	31.5	0.29	32.6
Back River	1968	1,260,000	169	0.19	120
	1975	1,390,000	191	0.20	139
	2000	1,870,000	281	0.22	206
Patapsco	1968	113,000	13.0	0.19	10.7
	1975	315,000	37.0	0.20	31.5
	2000	872,000	113	0.22	96.0
Cox Creek	1968	45,000	5.6	0.22	5.0
	1975	70,000	9.1	0.23	8.1
	2000	133,000	19.0	0.25	16.6
Savage	1968	8,000	1.0	0.26	1.0
	1975	26,000	3.4	0.27	3.5
	2000	157,000	25.0	0.29	22.8
Annapolis	1968	32,000	4.0	0.19	3.0
	1975	48,000	6.3	0.20	4.8
	2000	166,000	22.0	0.22	18.3
Broad Neck	1968	-	-	-	-
	1975	48,000	6.2	0.27	6.5
	2000	148,000	20.0	0.29	21.5

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Suspended Solids Removal (%)	Raw Sludge (dry tons/Day	Digestion Loss (%)	Digested Sludge (dry tons/day)	Waste Chem. Sludge (dry tons/day)	Total Digested + Waste Chem. Sludge (dry tons/day)
85	3.6	40	2.1	-	2.1
90	6.4	40	3.8	-	3.8
100	17.7	40	10.6	3.6	14.2
-	-	-	-	-	-
90	14.6	40	8.8	-	8.8
100	32.6	40	19.6	6.6	26.2
85	102	25	76.3	-	76.3
90	125	40	76.3	-	76.3
100	206	40	123.6	58.3	181.9
45	5.0	35	3.2	-	3.2
90	28.3	40	17.0	-	17.0
100	96.0	40	57.6	23.6	81.2
55	2.7	40	1.6	-	1.6
90	7.3	40	4.4	-	4.4
100	16.6	40	10.0	4.0	14.0
75	0.8	40	0.5	-	0.5
90	3.1	40	1.9	-	1.9
100	22.8	40	13.7	5.2	18.9
45	1.4	30	1.0	-	1.0
90	4.3	40	2.6	-	2.6
100	18.3	40	11.0	4.6	15.6
-	-	-	-	-	-
90	5.8	40	3.5	-	3.5
100	21.5	40	12.9	4.2	17.1

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APPENDIX C

ECONOMICS OF PIPELINING WASTE MATERIALS

In the analysis of the study areas in this report, it has been shown that pipelines can offer significant economic advantages over other means of transportation of waste materials. This finding may be of interest to pollution control authorities for other areas, which may have widely differing waste volumes and transportation distances than those encountered in the detailed case studies. The following information will allow an evaluation of pipeline costs for transportation of digested sludge and dredgings for a wide range of combinations of distance and waste quantity.

Extraction of pipeline capital and annual operating costs from Figures C-1 to C-6 is relatively simple. However, the use and limitations of the figures do warrant some discussion.

DIGESTED SLUDGE TRANSPORTATION COSTS

The capital costs of pipeline systems for transportation of 3.5% digested sludge are given in Figures C-1 and C-2. Figure C-1 shows pipeline installation costs as a function of throughput (i.e. pipe diameter) for downtown, suburban and rural construction. Figure C-2 shows the remaining capital cost items as a function of distance transported for various throughput levels. The total capital cost of a pipeline system, including installation, pipe, pump stations, right-of-way and indirect costs are included in Figures C-1 and C-2. The following is an example of the use of the tables.

Example: Determine the capital cost of a pipeline to transport digested sludge from a sewage treatment plant producing 500 tons of solids per day to a disposal site 100 miles away. The pipeline route will have 10 miles through downtown areas, 20 miles through suburbs and 70 miles through open country.

Pipe Installation Costs

	Unit Cost From Fig. C-1 $/ton mile	Miles	Tons/day Transported	Cost ($)
Downtown	115	10	500	575, 000
Suburban	75	20	500	750, 000
Rural	58	70	500	2, 040, 000
			Total Cost	$ 3, 365, 000

Capital Cost (Excluding Pipe Installation)

From Figure C-2, unit transportation cost for 500 tons/day and 100 miles distance is $180 per ton mile.

Therefore capital cost (excluding pipe installation)

$$= 180 \times 100 \times 500$$

$$= \$9,000,000$$

Total Capital Cost

Total Capital Cost = 3, 365, 000 + 9, 000, 000

= $12, 365, 000

Figure C-3 shows the annual direct operating costs of sludge pipelines as a function of distance for various throughput levels. The costs include power, labor, supplies and maintenance.

For the example given above, the unit annual operating cost for a 100 mile, 500 ton per day sludge pipeline, from Figure C-3, is $8 per daily ton per mile.

Therefore, the total direct operating cost of the pipeline is

8 x 500 x 100 = \$400,000 per year

Dredgings Transportation Costs

Figures C-4 to C-6 show the capital and direct operating costs for the pipeline transportation of maintenance dredgings. The curves are based on dredgings at 25 percent solids by weight and should be used in the same way as Figures C-1 to C-3.

Capital costs obtained from these figures include pipe and pump station installation, pipe, pump stations, right-of-way and indirect costs. Operating costs include power, labor, supplies and maintenance.

FIGURE C – 1

F.W.P.C.A. Waste Management Study

ECONOMICS OF PIPELINE TRANSPORTATION OF DIGESTED SLUDGE

PIPELINE INSTALLATION COSTS vs. CAPACITY FOR THREE CONSTRUCTION ZONES

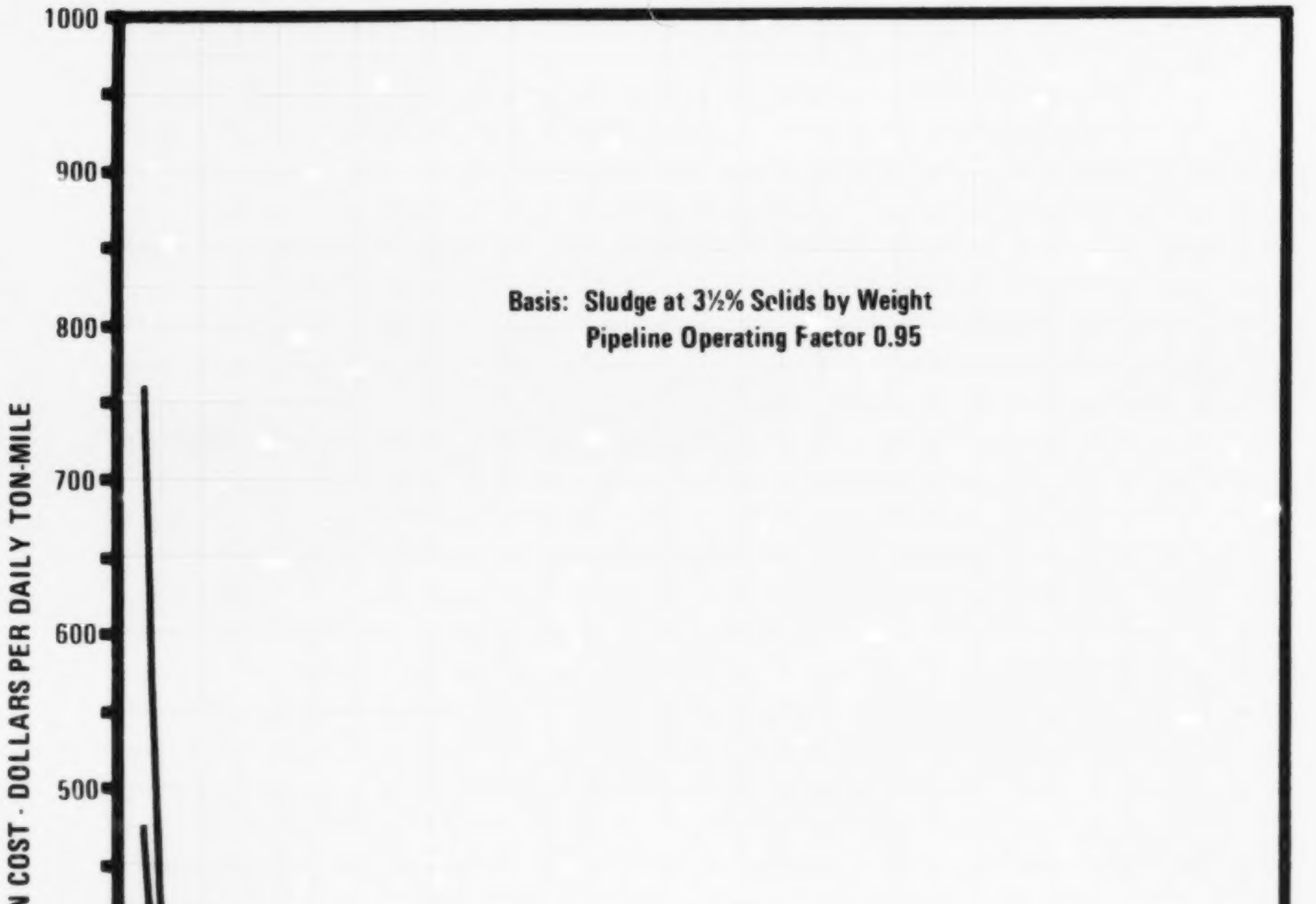

FIGURE C – 2
F.W.P.C.A. Waste Management Study
ECONOMICS OF PIPELINE TRANSPORTATION
OF DIGESTED SLUDGE
CAPITAL COSTS (Excluding Installation) vs. DISTANCE
FOR VARIOUS THROUGHPUT LEVELS

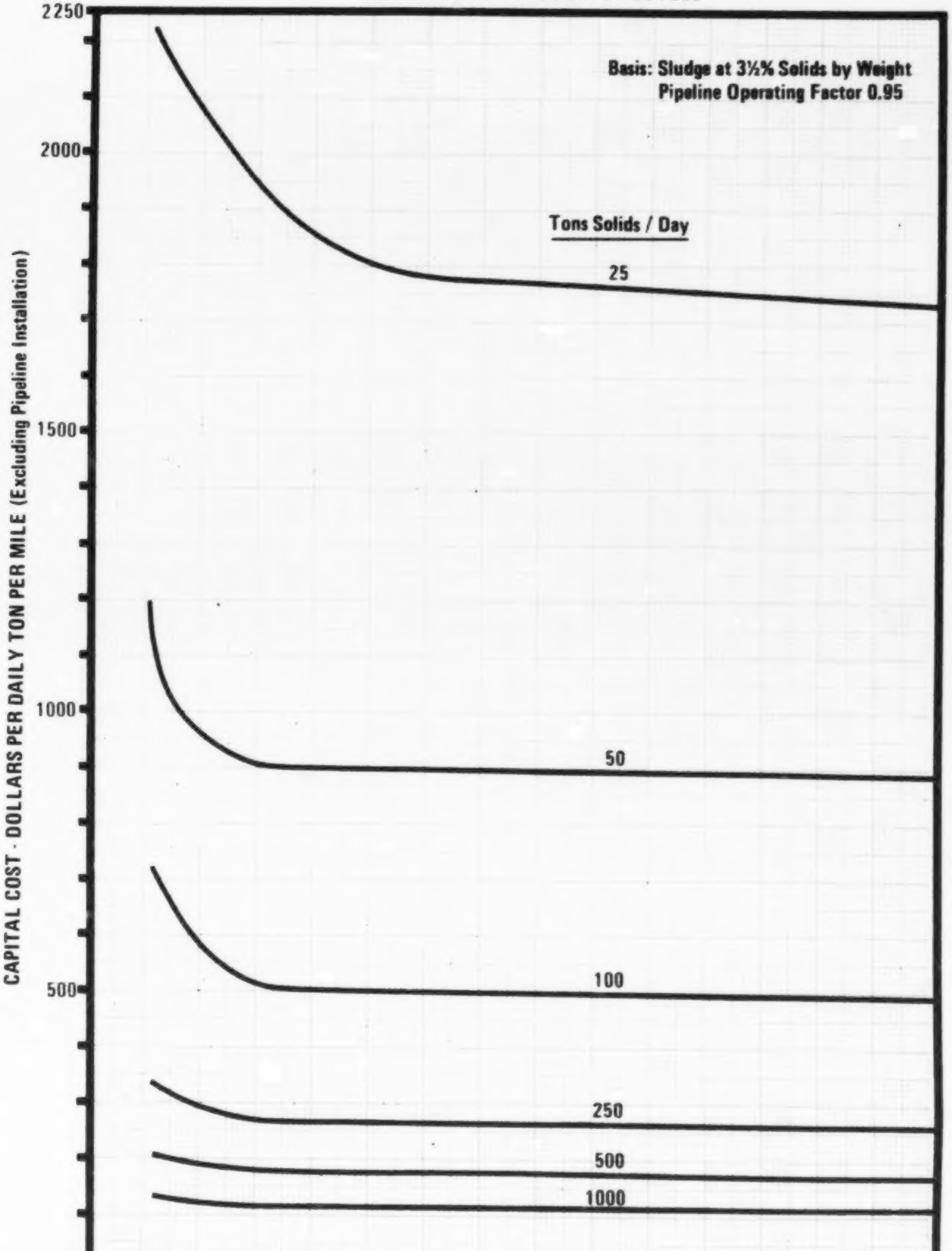

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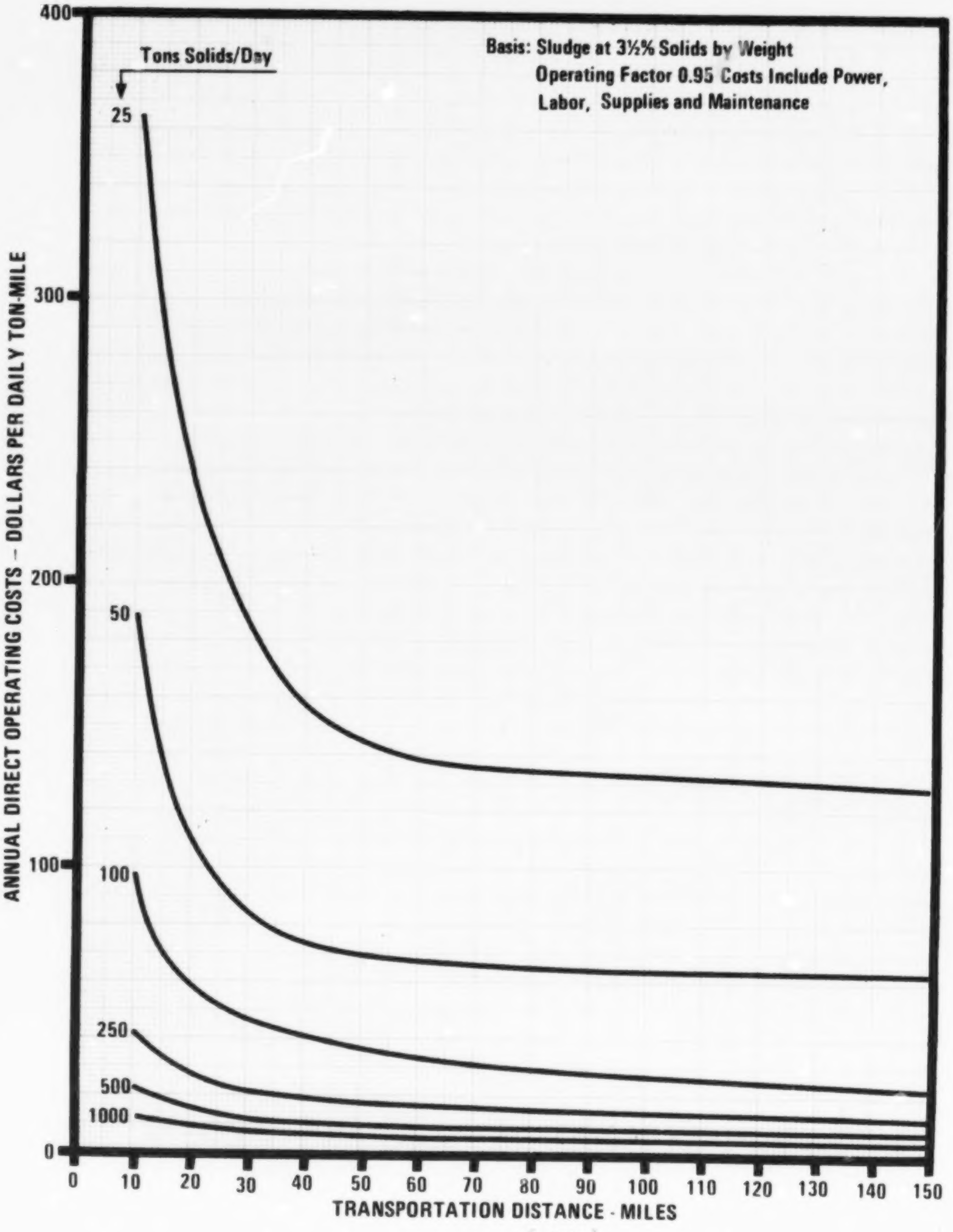
FIGURE C–3
F.W.P.C.A. Waste Management Study
ECONOMICS OF PIPELINE TRANSPORTATION
OF DIGESTED SLUDGE
DIRECT OPERATING COSTS vs. DISTANCE
FOR VARIOUS THROUGHPUT LEVELS

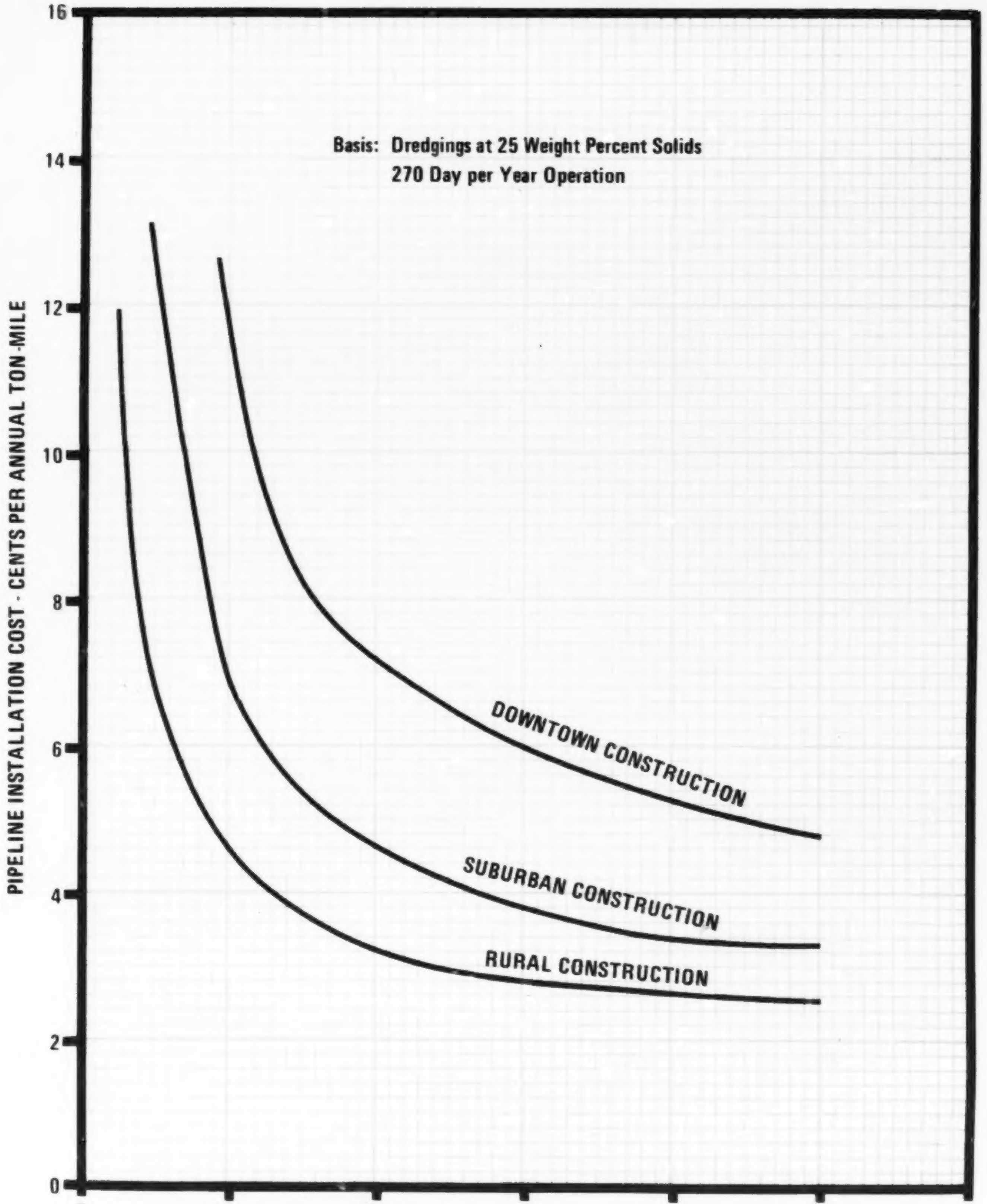


Basis: Sludge at 3½% Solids by Weight
Operating Factor 0.95 Costs Include Power,
Labor, Supplies and Maintenance

FIGURE C – 4

F.W.P.C.A. Waste Management Study

ECONOMICS OF PIPELINE TRANSPORTATION
OF MAINTENANCE DREDGINGS
PIPELINE INSTALLATION COSTS vs. CAPACITY
FOR THREE CONSTRUCTION ZONES



Basis: Dredgings at 25 Weight Percent Solids
270 Day per Year Operation

FIGURE C – 5

F.W.P.C.A. Waste Management Study
ECONOMICS OF PIPELINE TRANSPORTATION
OF MAINTENANCE DREDGINGS
CAPITAL COST (Ex Installation) vs. DISTANCE
FOR VARIOUS THROUGHPUT LEVELS

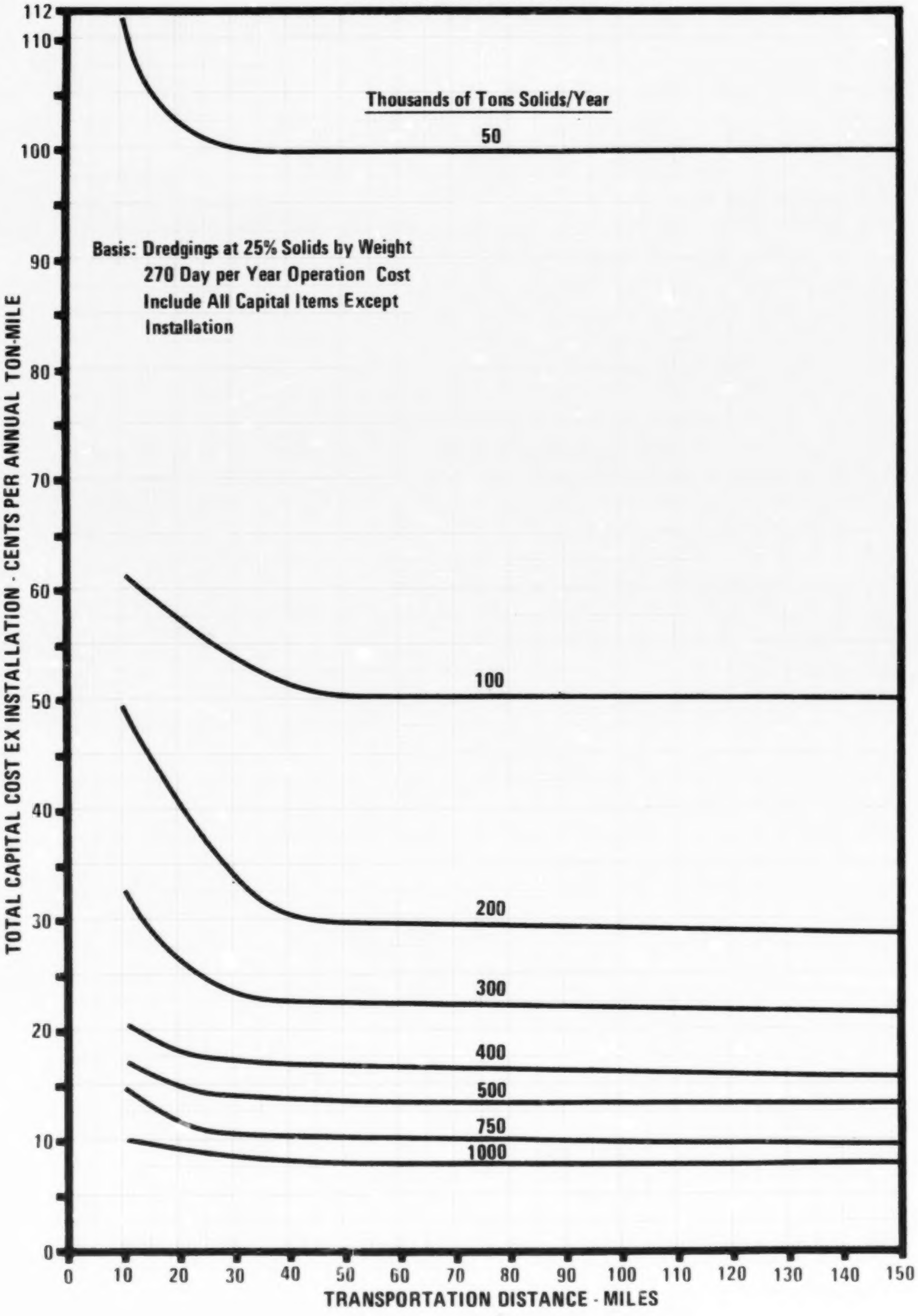
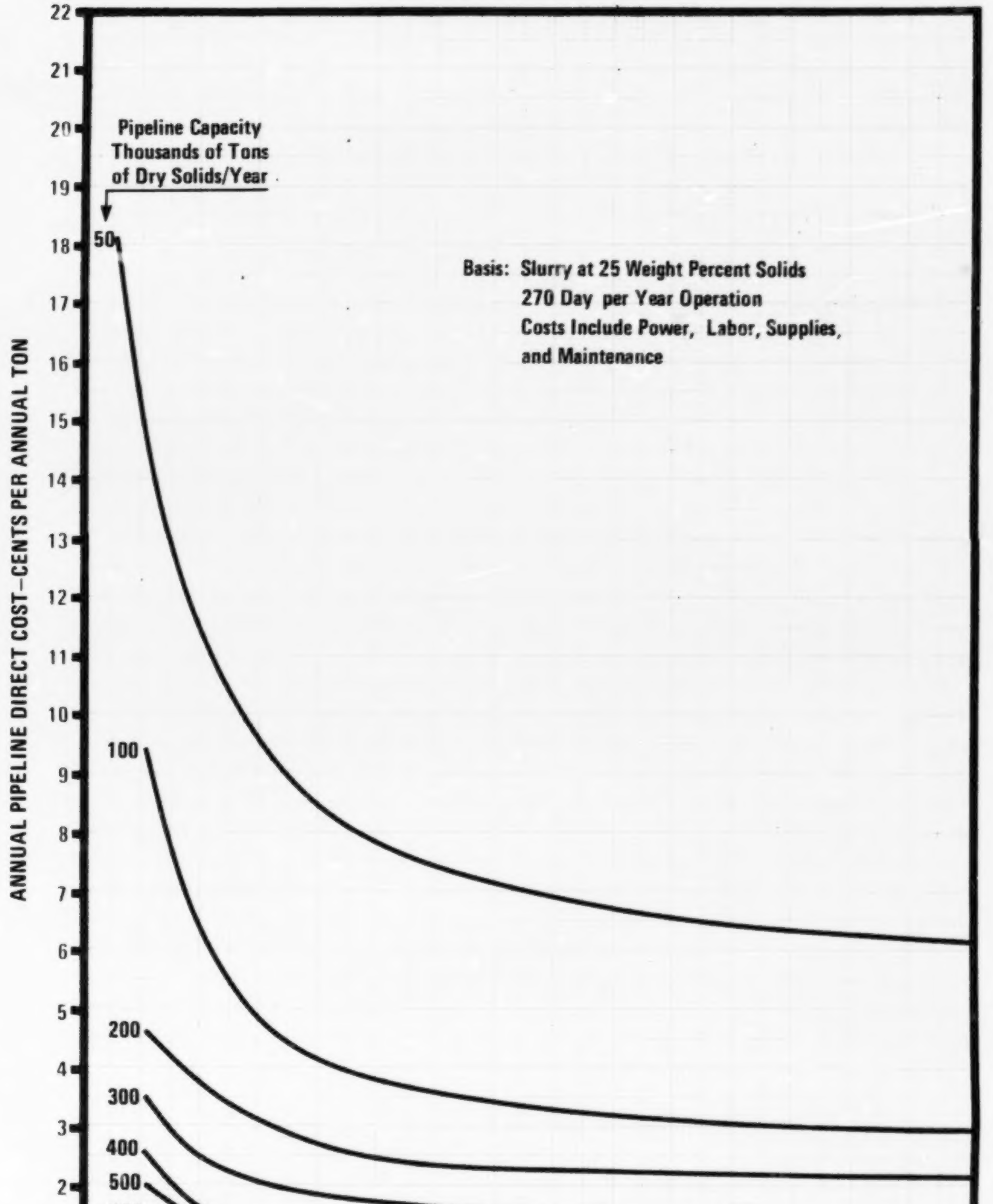


FIGURE C –6

F.W.P.C.A. Waste Management Study

ECONOMICS OF PIPELINE TRANSPORTATION OF MAINTENANCE DREDGINGS DIRECT OPERATING COSTS vs. DISTANCE FOR VARIOUS THROUGHPUT LEVELS



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APPENDIX D

PRESENT METHODS & COSTS OF DISPOSAL

NORTHEAST OHIO REGION

Digested Sludge

Wastewater treatment methods are similar for all plants considered in this study. Except for Cleveland Westerly, which is a primary facility, all provide activated sludge treatment. Furthermore, as shown in Table D-1, all plants practice digestion and all except Canton utilize vacuum filtration. Cleveland Easterly is not included in this table, as all raw sludge from this plant is pipelined to Southerly for disposal.

EXISTING SLUDGE DISPOSAL METHODS
NORTHEAST OHIO WASTEWATER TREATMENT PLANTS

Cleveland Southerly	Digestion, Vacuum Filtration & Incineration
Cleveland Westerly	Digestion, Vacuum Filtration & Incineration
Canton	Digestion and Land Disposal
Lakewood	Digestion, Vacuum Filtration & Flash Drying
Akron	Digestion, Vacuum Filtration & Incineration

From Table 2, it is seen that Southerly is the source of nearly half of the total sludge from the five plants. Detailed unit process cost studies for this plant have been regularly prepared for many years. In Table D-1, an operation summary of plant loadings and sludge quantities is presented for the years 1965 through 1968. A cost summary of the direct costs of vacuum filtration and incineration is presented in Table D-2 for the period 1960 through 1967(11) with a detailed breakdown for the last three years. From this data, the following observations can be made:

TABLE D-1

F. W. P. C. A. Waste Management Study

OPERATION SUMMARY

PLANT LOADINGS & SLUDGE QUANTITIES

CLEVELAND EASTERLY & SOUTHERLY SEWAGE TREATMENT PLANTS

	1965	1966	1967	1968
FLOW (Million gal. /day)				
Easterly	116.0	120.7	123.6	125.7
Southerly	77.4	74.1	62.6*	67.3*
Total	193.4	194.8	186.2	193.0
SUSP. SOLIDS IN RAW SEWAGE (Dry tons/day)				
Easterly	75.0	77.0	76.8	81.2
Southerly	65.9	60.4	53.8*	54.0*
Total	140.9	137.4	130.6	135.2
SUSP. SOLIDS REMOVED (Dry tons/day)				
Easterly	62.7	64.0	65.4	68.1
Southerly	54.3	50.6	45.2	44.4
Total	117.0	114.6	110.6	112.5
DIG. SLUDGE TO INCINERATOR (Dry tons/day)	38.9	29.5	24.0	41.8
SUPERNATANT LOSS TO SEWER ** (Dry tons/day)	24.0	25.9	37.2	30.0

* Raw sewage was diverted from Southerly in 1967 and 1968 due to major sewer breaks.

** From secondary digesters.

TABLE D-2

F. W. P. C. A. Waste Management Study

COST SUMMARY

VACUUM FILTRATION & INCINERATION

CLEVELAND SOUTHERLY
SEWAGE TREATMENT PLANT

Year	Tons of Dry Solids Incinerated	Direct Cost Vacuum Filtr. & Incin. ($/ton)
1967	8,753	46.54
1966	10,782	36.38
1965	14,210	25.39
1964	14,223	25.47
1963	14,562	24.62
1962	14,195	25.81
1961	12,686	30.00
1960	15,533	21.86

	1965	1966	1967
Chemicals	95,143	85,681	79,839
Fuel Oil	18,534	43,120	47,687
Electric Charges	30,236	28,629	23,681
Sub-Total	143,913	157,430	151,207
Operation: Labor	157,358	161,289	180,384
Sub-Total	301,271	318,719	331,591
Maintenance: Labor & Materials	59,582	73,484	75,812
Total Direct Costs	$ 360,853	$ 392,203	$ 407,403
Digested Sludge to Incineration (dry tons/year)	14,210	10,782	8,753
Direct Costs in $/ton*	$ 25,39	$ 36.38	$ 46.54

* Direct costs include only out-of-pocket expenses incurred daily on a routine schedule and directly attributable to the physical requirements of the process.

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1. The total raw sewage flow and suspended solids load to the combined Easterly and Southerly operation has remained relatively constant for the last four years. This is partly due to major sewer breaks that have occurred at Southerly during the last few years.

2. Suspended solids removal has been about 84% for this period with little yearly variation shown.

3. The amount of solids sent to the incinerator has averaged about 30% of the suspended solids removed. Part of this difference is accounted for by digestion losses. However, the total to the incinerator would nearly double if all suspended solids in the supernatant were included. Loss of fines from supernatant has been recognized as one of the major unsolved operating problems at Southerly for many years.

4. The direct costs of sludge filtration and incineration have averaged about $25/ton over the period 1960-1965. The marked increase in unit costs in 1966 and 1967 is attributable to the sharp falloff in the amount of sludge incinerated.

Anticipated Future Changes

Local officials have recognized the need for further upgrading of all wastewater treatment facilities, including improvements in solids disposal. As a result, various studies have been made and programs recommended. Among the improvements anticipated are:

1. Provision of secondary treatment at Cleveland's Westerly plant. The existing old and obsolete sludge disposal facilities would be replaced by new vacuum filtration-incineration equipment. (12)

2. Expansion of primary and secondary treatment facilities at both the Easterly and Southerly plants. (6)

3. Digester heating improvements at Southerly. (6)

In addition, it is possible that Lakewood may change its method of sludge disposal unless there is an increase in demand for the dried sludge. A change in sludge disposal is currently being considered by Canton.

Maintenance Dredgings

Maintenance dredging is performed annually by the Corps of Engineers at two projects in the study area, namely, Cleveland Outer Harbor and the Cuyahoga River. At both locations, the material removed is mostly sand and silt and has been classified by the F. W. P. C. A. as being polluted in the harbor and heavily polluted in the river.

Previously, dredged material was invariably disposed of by bottom dumping from hopper dredges or dump scows into established dump grounds in the lake. The bulk of the dredgings were spoiled in a recently established disposal area, which begins 1/2 mile northeast of the east outer breakwater of Cleveland Harbour.

However, the advisability of prolonged open-lake dumping and in effects on the ecology of the lake area has been the subject of considerable study of late (5). A possible alternate for open-lake disposal is the use of diked disposal areas located along the lakefront and in the Cuyahoga River. In fact, the Corps of Engineers has already embarked on a pilot study of disposal to diked areas and a 2 million cubic yard lagoon is being constructed in Lake Erie for this purpose.

The costs of both methods, open-lake and diked area disposal, have been given extensive coverage in a recent publication by the Corps (5). Included in this information are the costs related to the specific area of concern to this study. Table D-3 shows these costs which include direct operating and all capital charges.

TABLE D-3

MAINTENANCE DREDGINGS DISPOSAL COSTS (5) FOR CLEVELAND HARBOR AND CUYAHOGA RIVER

(1969 Costs)

COST	OPEN LAKE DUMPING	DISPOSAL TO DIKED AREAS
$/cu. yard	0.78	1.89
$/ton solids*	1.25	3.03

* Based on 1,250 lbs. of solids per cubic yard of dredged material.

(153)

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Digested Sludge

In this study, a regional ocean disposal system was proposed which would take digested sludge from sixteen waste-water treatment plants. As of the end of 1968, three of these plants were not yet in operation, namely Pohick, Western Branch and Broad Neck. Of those presently operating, land disposal of dewatered sludge is the predominant method.

At the smaller plants, such as Parkway, Belair-Bowie and Cox Creek, sludge drying beds are utilized. At the D. C., Arlington and Patapsco plants, the sludge is sent to vacuum filters and the cake is disposed of at the plant site. Back River uses heat drying prior to disposal.

Unfortunately unit process cost studies were not available on the existing sludge disposal methods. However, a recent development plan for the District of Columbia Water Pollution Control Plant, which is by far the largest plant to be served, indicated that excluding ocean disposal, multiple hearth incineration would be the cheapest method of disposal. At an annual flow of 309 MGD, disposal costs would be $57.30 per ton, including amortization. For the projected flow of 419 MGD in the year 2000, costs would be $52.80 per ton. Included in these figures are the costs for air pollution control equipment but the cost of nutrient removal from supernatant, filtrate, etc., is excluded. The estimated capital cost of sludge handling including facilities for thickening, flotation, dewatering and incineration to meet the requirements in the year 2000 is projected at about $30 million.

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Sludge transport, Solid waste disposal.

27 *Abstract*

Development of a specific waste management system which collects, transports and disposes of sewage sludge and maintenance dredgings in a socially, technically, and economically satisfactory fashion was studied by systems analysis. The feasibility of constructing and operating a demonstration project was examined. A major effort in this area is the demonstration project by the Metropolitan Sanitary District of Greater Chicago using sewage sludge for agriculture. For each detailed study case, a disposal system is proposed which effectively serves regional needs, is economically sound, and includes the collection, transportation and disposal of the estimated production of wastes up to the year 2000. The economics of the systems are presented and recommendations are made as how to achieve both immediate and long-term objectives. For an immediate solution to the national problem of waste disposal of digested sewage sludge, a land disposal system is recommended. A long-term, successful history of beneficially using sludge on land is available. The cost benefit ratio of the sludge disposal system is very favorable. A demonstration project is recommended to prove the viability of the concept. Pipeline transportation is economically better than the other modes evaluated. (Knapp - USGS)

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